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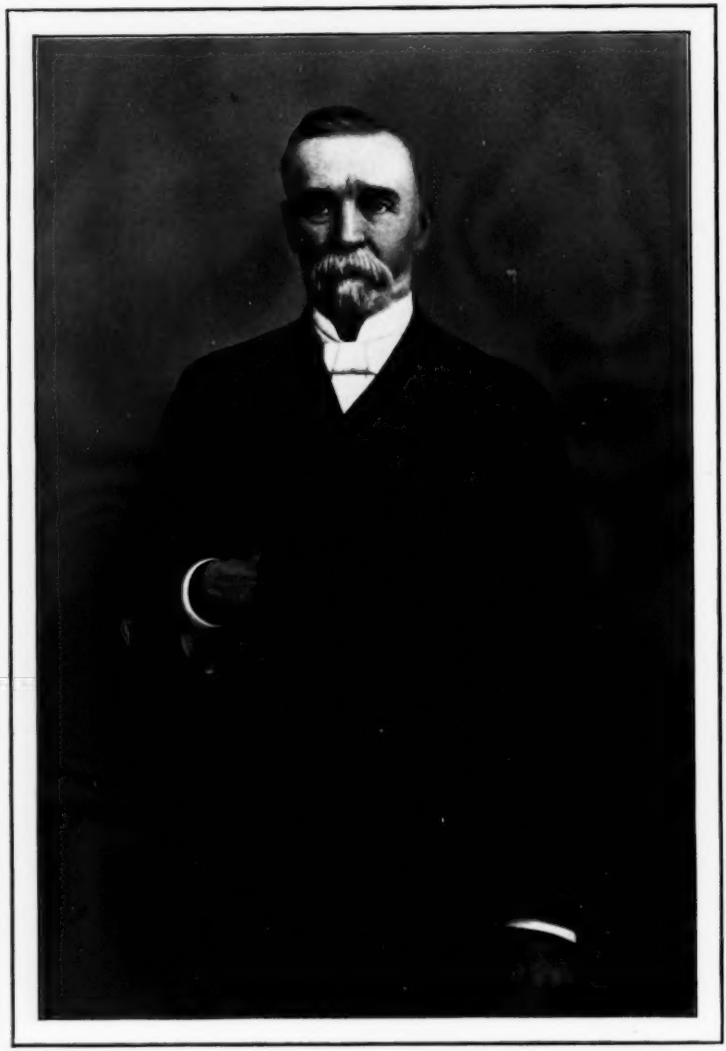

JOHN FRITZ.

From the original painting by Paul Hercher, in the possession of the American Society of Mechanical Engineers.

THE ENGINEERING MAGAZINE

THE WORLD IS ITS FIELD

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THE PANAMA CANAL, AND THE REGULATION OF THE CHAGRES RIVER.

By Gen. Henry L. Abbot. With an Editorial Introduction.

NOW that the best route for the Isthmian Canal has been chosen, the matter of prime importance is the detailed project for doing the work. And in the construction, as in the selection, no consideration should prevail except the clear purpose to have the best. The only safe course,—the only permissible course—is to learn every obtainable fact, and to devote the ablest and most unfettered engineering talent to the work of planning and building as the facts require.

It is with great pleasure, therefore, that THE ENGINEERING MAGAZINE again welcomes to its pages so able and dignified an expositor as General Abbot, and serves as the medium for him to place before the engineering public an abstract of the wonderful fund of data in his possession. These concern the key to the success of the Panama Canal—the Chagres River. Misunderstanding and misstatement about the river have rioted more wildly than its worst floods. It is part of the result of General Abbot's discussion to show that the Chagres is in fact "far from a menace—a most useful friend," "supplying all the water that can ever be demanded by any probable traffic for centuries to come," and yet with judicious regulation giving no annoyance to shipping on any part of the route. To the student of the hydraulics of rivers the following article will be of the utmost possible

interest in its presentation of methods and data—a revelation in the systematic and elaborate study of the regimen of a stream. To everyone interested in the Isthmian Canal it will be a valuable demonstration of the soundness of the studies which have led to the adoption of the Panama line, the certainty that no menace need be feared from the floods of the Chagres, the assurance of a certain water supply for the summit levels, and last, but by no means least, the proof that the one-lake project adopted tentatively by the Isthmian Canal Commission, while perhaps sufficient for the preliminary and comparative studies, is not at all sufficient as a working plan. A little more than half of General Abbot's article is given to the general discussion of the Chagres river and contains many facts not before in print about the topography of its basin, its regimen, its discharge, its floods, and their regulation. This alone will dispel many widespread errors of belief, and show that far from being a stream *sui generis,* practically beyond control by ordinary methods, it is really less formidable than a class of streams engineers are entirely accustomed to improve. It is, indeed, extraordinarily similar in its flood-behavior to the Roanoke River, above Neal, North Carolina. It has never approached such extremes of oscillation or rapidity of rise as are shown by the Warrior and Black Warrior Rivers of Alabama. The highest flood ever known did not reach 40 feet; the most rapid rise was 25 feet in 17 hours. Such oscillations would not attract more than passing notice in the river cities of the western United States. If General Abbot did no more than refute such wild exaggerations as the "52-feet rise in 2-hours" myth his paper would have served a valuable purpose.

But the second half is of even more importance. The entire feasibility of regulating the Chagres is well understood by most engineers—certainly settled beyond question with the Commission. But the best method of securing both regulation and conservation of the water supply to feed the canal during the dry season is in more danger of misapprehension. The Isthmian Canal Commission, being under great pressure for an early report, had no time to investigate details; their function was to determine route, not working plans. They adopted, merely as a peg upon which to hang a comparative cost estimate, the "single-lake plan"—that is, one by which the Chagres is to be confined in one great summit lake by a single dam at Bohio, 27 miles from the sea. The fear is now that a new commission, perhaps similarly urged to haste in putting the work in hand, may accept the conclusion of their predecessors on their high authority, without finding time for the study which the subject really demands.

General Abbot's figures and reasoning show clearly that this would be a grave mistake. The objections are, briefly:—That to store in the one lake sufficient reserves for operation and wastage would involve a dam and a summit level higher than desirable for convenient lockage; further, the increased head above the dam would occasion larger loss by infiltration through the underlying strata, partly defeating its own purpose; and again, even at the utmost height which could be contemplated, the single lake would still receive the Chagres with flood force near Gamboa, and objectionable currents and possible silting up, with attendant necessity for frequent dredging, would interfere with navigation.

The alternative is the two-lake project, determined by the exhaustive studies of the *Comité Technique*—an international and unbiased body of engineers of the highest eminence and quite unhampered in the matter of time or expense in their investigations. By building a second dam at Alhajuela, 29 miles above the first, they would make *two* storage reservoirs, and gain the following advantages:—The lower reservoir, constituting the summit level of the canal, might have much less elevation above sea, as it would be required to store only about two-fifths of the flood reserves. The lowering of the Bohio dam, thus permitted, would reduce the head to 70 feet, greatly diminishing both the height of lockage and the danger of loss by leakage through the bottom strata; and the stream entering this lower lake could be so controlled at the second dam, confining the upper lake, as never to cause the slightest inconvenience or delay to navigation.

These are the conclusions reached by the *Comité Technique*—a commission including some of the most distinguished hydraulic engineers of the world—after careful and deliberative examination of the results of twenty years' systematic study. General Abbot condenses into the following article and its tables and figures the most important of the data deciding this view.—THE EDITORS.

THE long series of measurements made during the construction of the Panama Canal, and especially during the operations of the New Company, have given a knowledge of the Chagres river probably more definite and exact than that respecting any river of its size in the United States. It therefore possesses an interest to students of the hydraulics of rivers quite independent of its relations to the Isthmian Canal. Having made a careful personal inspection of its course from near its mouth to a point several miles above the site of the dam projected near Alhajuela, and having made a professional

study in detail of all the data collected by the two canal companies since the date of the commencement of operations in 1881, I have considered that a presentation of the facts bearing upon the physics and hydraulics of the stream, and upon its regulation for the purposes of a canal, might not be other than a useful contribution at the present time.

Topography of the Basin above Bohio.—The river heads in the Cordillera de San Blas, which here forms the continental divide and separates its waters from the Pacific. Two principal branches constitute the stream; one, known as the Pequeni, heads only about 5 miles from the Atlantic coast near Porto Bello; the other, which takes the name Chagres, although contributing less water than the Pequeni, heads in a direction a little south of east from this point and at an approximate distance of about 20 miles. The branches unite about 8 miles by the channel (3 as the crow flies) above Alhajuela, where is located one of the gauging stations of the New Company, just below the projected dam site.

This upper basin of the Chagres has been little explored, and the boundaries of its northern and eastern watersheds have never been traced. The region is covered with a dense forest of tropical vegetation, and the stream winds among low ridges believed not to exceed a thousand or fifteen hundred feet in height. For a few miles above Alhajuela the channel is bordered by limestone bluffs, passing below the stratified calcareous sandstone of the lower river, and often deeply undercut by the freshets of the torrential stream. The rock at a few localities is nearly white, and is sometimes worn into fantastic forms and draped by overhanging vegetation characteristic of the tropics. Rapids are here much more frequent than in the lower river. Taken as a whole, few regions offer greater natural beauties.

The middle sub-basin, lying between Alhajuela and Gamboa where the river joins the route of the canal, was traversed in a canoe in March, 1898, the water being about a foot above low-water stage. The total distance was about 11 miles, the width of the waterway being 100 to 300 feet, the channel depth about 3 feet, and the current ranging from 3 to 6 feet per second, giving a discharge of about 800 cubic feet. Eighteen rapids were counted, several of them requiring hard poling to surmount. The bed presented one marked peculiarity not seen in rivers having a regimen less torrential—the bars differed widely in composition. Some were of pure sand, others of pebbles, others of rounded stones 3 or more inches in diameter; there was little or no intermixing of materials. Evidently this peculiarity is due to the frequent freshets of the rainy season, which differ materially in vol-

ume and velocity and hence in transporting power. The water was beautifully clear; but the banks, although often of rock or protected by vegetable growth, were occasionally of clay showing evidence of moderate caving in times of high water.

In the lower sub-basin between Gamboa and Bohio the channel enlarges and the rapids in great part disappear. The caving banks increase in number, but as the entire region will be flooded by the projected lake, and thus be protected against erosion, this feature has no practical importance.

Regimen of the Chagres. The fact that the Chagres above Gamboa is essentially a clear-water stream was so well understood by the engineers of the New Company that no observations to determine the amount of earthy matter carried in suspension were deemed necessary. Fortunately, in view of the reckless misstatements that have been made respecting this element of the problem, the Isthmian Canal Commission investigated the volume of sedimentary matter quantitatively both for the Chagres and for the San Juan river at Sabalos Station near where it issues from Lake Nicaragua, and where naturally the water must be exceptionally pure. The results are presented for comparison in the first half of the following table, the second half being added to show the corresponding total discharges of the rivers as indicated by the gaugings of the Commission.

Month 1900	Solid matter in cubic yards at			Total discharge in acre-feet.		
	Alhajuela.	Bohio.	Sabalos Station.	Alhajuela.	Bohio.	Sabalos Station.
June	15,180	30,540	143,480	115,080	189,520	741,117
July	.....	152,760	207,762	.....	366,470	1,073,149
August	81,230	116,000	166,247	251,730	361,550	1,288,735
Sept.	41,660	79,360	122,595	184,520	308,830	1,266,473
Oct.	97,000	.....	113,203	300,610	.....	1,752,367

Although these data are not reported in a unit permitting a comparison with similar observations on other streams, they make it evident that the volume of sedimentary matter which will be carried in suspension to Lake Bohio will have no practical importance. Whatever comes down will be deposited near the entrance where it can easily be removed by dredging. It is true that, in addition, some sand and gravel will be rolled along the bottom, but the volume will be unimportant, especially if the precaution be taken to regulate the freshets as well as the floods by an upper lake at Alhajuela.

The tributary streams below Alhajuela, although insignificant in the dry season, carry considerable volumes at times during the rainy months, and are not without importance in the problem of regulation. Seventeen of them enter between Alhajuela and Gamboa and fifteen

thence to Bohio; and there are about thirty below. Several of them were gauged both by the Company and by the Commission, but as will appear below the results need not be considered here in detail.

Not only have the level surveys of the two companies given precise information as to the slopes and more important contours of the valley above Bohio, but fluviographs established at Gamboa in 1882, at Bohio before 1890, and at Alhajuela in 1899, have furnished a nearly continuous automatic record of river stages covering about twenty years. That at Gamboa where the Chagres first joins the canal was naturally regarded as the most important and is the most complete.

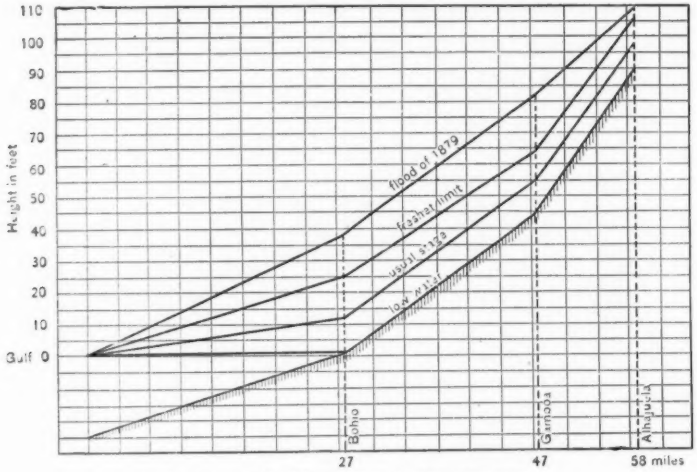


FIG. I. CHAGRES RIVER, VERTICAL SECTION.

The mean tidal oscillation at Colon, based on sixty months of daily observations between 1882 and 1887, is 1.43 feet, ranging from a maximum of 2.07 feet to a minimum of 0.62 feet. In extreme low water of the river the tidal level extends sensibly to Bohio, where a slight tidal oscillation of a few inches then appears. Ascending the river from this point the slope of the bed rises rapidly; and, as already stated, many rapids appear above Gamboa at low stages. They play an important part in the regimen of the stream, since they hold in reserve certain differences of level which when the river rises furnish an effective motive power to carry forward the increased volume, and thus reduce the oscillation between high- and low-water level. For example, the maximum variation noted during the past half-century at Bohio was 39.4 feet, becoming at Gamboa about 37.7 feet, while at

Alhajuela, although no authentic records are available, it could hardly have exceeded 18 feet. Relations like these can be better presented graphically than by tables, and attention is invited to Figure 1 for details.

As in all the rivers, there are considerable variations in the dimensions of the waterway at different localities near each other, but the following table giving those at the three gauging stations may be considered to represent the channel fairly under normal conditions in the neighboring parts of the valley. In it "height" refers to elevation above mean tidal level, and "velocity" to the maximum rate of flow as measured by surface floats following the thread of the current at the stages indicated.

	Alhajuela, sea 58 miles.				Gamboa, sea 47 miles.				Bohio, sea 27 miles.			
River stage.	Height, ft.	Width, ft.	Area, sq. ft.	Veloc., ft.	Height, ft.	Width, ft.	Area, sq. ft.	Veloc., ft.	Height, ft.	Width, ft.	Area, sq. ft.	Veloc., ft.
Low water ..	92	232	689	1.0	46	170	1,250	1.1	1	189	615	2.1
Usual stage..	99	248	2,239	10.8	56	188	3,014	6.9	13	236	3.079	5.9
High freshet.	107	284	4,661	12.1	70	over bank		14.1	26	288	6,362	7.9
Flood limit..	110?	381	5,834	?	83	over bank		?	39	over bank		?

The lowest water level of record occurred in April, 1901, being at Alhajuela 28.0 metres (91.86 feet), at Gamboa 13.72 metres (45.0 feet), and at Bohio 0.14 metres (0.46 feet) above mean tide. For convenience, the low stage at these three posts has been assumed as 28 metres, 14 metres, and 0 metres respectively; the superior limit of usual stages being 30 metres, 17 metres, and 4 metres. It may be remarked here that, as all the records and computations have been made in metric units, some slight discrepancies may be noted in this paper, due to the transformation into English units involving the neglect of small fractions.

The river year on the Isthmus is sharply divided, this being due to the marked variation in rainfall, which, inconsiderable in January, February, March, and April, is heavy in the eight other months. The great floods have always occurred in November or December. It is by a study of the very complete registers of the fluviograph at Gamboa that the regimen of the Chagres is best understood. Nearly twenty years are available, and the chief difficulty is to arrange the important elements in the most compact form for examination. This is attempted in the first table in the Appendix,* which gives the number of times in each month that the river rose above 17 metres (the begin-

* See page 367, this issue.

ning of freshets, 10 feet above dead-low water); the total number of hours in each month that it remained above this level; the highest level attained in each month above dead-low water (14 metres); and finally the local rainfall in inches. For a few months, exact figures showing the greatest height attained above low water are not at hand, although the fact is of record that it did not reach the 17-metre stage; in such cases the word "less" will be found in the table.

This tabular exhibit warrants important conclusions, which will be confirmed by the tables of discharge. February and March are the extreme low-water months, the river then rarely rising more than 3 feet above the lowest stage. January and April are similar, although small freshets sometimes occur, especially in January. The other months show slight differences among themselves, but are all characterized by freshets, averaging about three per month, but sometimes exceeding ten. They are of very short duration, the river rarely remaining above the 17-metre stage for four days in an entire month, and rising and falling rapidly. Nevertheless these freshets deliver considerable volumes of water, moving with high velocity and sweeping down the channel like great waves. The fluviograph records have enabled the rate of movement of their crests to be accurately noted; they traverse the 11 miles from Alhajuela to Gamboa in about 4 hours, and the 20 miles thence to Bohio in about 6.5 hours—indicating a rate of movement of about 4.5 feet per second, which of course is much less than that of the water itself. As will appear further on, investigations have shown that the interval of time which elapses between the heavy downpour of rain that causes a freshet and the arrival of its crest at Bohio varies from 24 hours to 48 hours, according to the locus of the storm. These facts make it evident that, with the system of telegraphic communication which will be demanded to operate the canal, an agent at adjustable waste weirs on Lake Bohio would have ample warning and could easily and judiciously regulate the level of that lake.

It should be understood that these freshets, notwithstanding their short duration, are the controlling feature in the monthly discharge, the volume carried sometimes increasing ten and even twenty times as they pass. Bearing this in mind, the following annual summary, covering the eight rainy months in the table in the Appendix, establishes the fact that there are considerable and progressive variations from year to year in the discharge; that during the operations of the old company the volume was excessive, culminating in 1886 and 1887; and that since that maximum it has diminished, apparently reaching

a minimum in 1898 and 1899. Data for accurate estimates of discharge do not exist prior to 1890, and therefore this evidence of annual variation covering several years is presented here, in the form of a summary of freshets at Gamboa. That the same condition affects lake Nicaragua has been conclusively shown by the Isthmian Canal Commission; and a study of the rain record at Colon, nearly complete since 1862, leads to the same conclusion.

Year.	No. of freshets.	Above 17 metres, hours.	Local rainfall, inches.
1883	21	201	70.5
1884	25	334	87.1
1885	37	437	95.7
1886	43	437	97.8
1887	39+	649+	126.9
1888	29	596	100.3
1890	34	308	95.2
1891	10	116	74.6
1892	24	269	95.3
1893	12	220	107.9
1894	25	263	87.6
1895	7	54	....
1897	14+	151+	102.5
1898	8	51	78.3
1899	8	57	70.5
1900	12	84	74.2
1901	13	107	90.0
Means	21.2	255	90.9

Discharge of the Chagres.—A trustworthy and safe valuation of the discharge of the river is naturally a matter of first importance in studying the project for a canal, and measurements were by no means neglected by the engineers of the old company; but when the work came under the control of the liquidator, and later under the New Company, a more systematic plan was put into operation. Detailed instructions were issued in September, 1889, defining the method to be followed, and it has continued in force up to the present time.

The location is carefully covered by seven transverse lines of soundings in parallel planes about 10 metres apart, which are frequently repeated to detect possible changes in the bed. Surface floats offering little resistance to the air, like bottles ballasted with water, are used to determine the velocity. They are started from a boat far enough above the base, which is from 60 to 80 metres long according to locality, to attain it with the full velocity of the water. The times of transit are noted to quarter seconds by the observer with the watch, the instants of passing the ranges being called out by the other observer who precedes the floats. Six transits are usually noted, two at the middle of the stream and the others about half-way to the banks.

Full reports, including water level at the fluviograph and every detail, are submitted. The discharge is estimated by taking eight-tenths of the product of the mean velocity, as measured, by the area of cross section. Since 1889, with but few intermissions, the discharge has been thus measured at three-day intervals, and more frequently in times of freshets, at Gamboa and Bohio. Daily measurements were made at Alhajuela in 1895 and 1896, and since April, 1899, when they were resumed. During the last three or four years occasional night observations have been attempted to secure additional determinations of the velocity in large freshets.

In considering this method of gauging, the problem before the engineers of the Company should be borne in mind. The vital question was to determine whether the Chagres will supply all the needs of the canal in the season of low water. Any reasonable doubt here would be fatal to the project of a canal with locks, and no over-estimate of discharge could be tolerated. Hence the adoption of the coefficient eight-tenths, when nine-tenths would probably accord more nearly with the fact. The value was certainly safe and conservative, and in the plans for flood regulation due allowance for its probable insufficiency was made.

It remains to consider how, from these numerous gaugings, to determine the volume carried by the river in stated periods, the monthly and yearly discharges, for example. The most obvious manner is to adopt the mean of all the daily measurements as the true mean for the period in question. The objections to this plan for a river so variable as the Chagres are apparent. Ten days per month are too few for a correct average, especially as freshets by night escape measurement, thus unduly reducing the numerical mean. On the other hand, the comparatively few gaugings during a freshet, when the discharge is undergoing almost momentary variation, are likely to furnish too large a volume, from the natural tendency to multiply observations at the higher levels, thus unduly increasing the numerical mean. Furthermore, as direct gaugings were not made in the great flood of 1879, the greatest of record and therefore the true standard for estimating the provisions needful for regulation, it becomes necessary to infer logically the true discharge at stages considerably above any actually measured. It is evident from these considerations that the problem can be solved in a satisfactory manner only by applying to the hourly stages, known from the fluviograph sheets, a rating table derived from the very numerous gaugings made between lowest and highest river stages.

The construction of a trustworthy rating table for a torrential river like the Chagres is by no means a simple problem. In all rivers the discharge at a given stage is always greater when the water is rising than when falling, owing to the greater local slope affecting the flow. To represent the river truly, the rating table must take account of this law by indicating the mean between the rising and falling branches of the curve, and this the mean of so many measurements will correctly represent. Such tables are often constructed by drawing an arbitrary line to reproduce as accurately as possible the average of the platted observations; but when it is needful, as in the present case, to extend the curve beyond the limit of the observations, the general law of its curvature should be studied and represented by a formula, thus extending this law to the unknown portion and eliminating arbitrary assumptions. As this unknown portion was less than 10 per cent. of the whole curve at Gamboa, and less than 20 per cent. at Bohio, it is safe to assume that the predicted maximum discharge can involve no serious error. In framing the formula either the method of least squares or the graphical method may be employed, but as the relative weight to be accorded to the higher observations was not easily estimated, the latter was preferred. The following formulæ resulted from the study, based for Gamboa on over 1,500 gaugings, for Bohio on over 1,000 gaugings, and for Alhajuela on over 500 gaugings. In them Q denotes the discharge in cubic metres per second, and C the height of the water level above mean sea level, in metres.

Alhajuela, $Q=-8+52(C-27.5)^2-1.6(C-27.5)^3$

Gamboa, $Q=-26+24(C-13)+18(C-13)^2-0.5(C-13)^3$

Bohio, $Q=47C+5C^2+C^3$

The accordance between these formulæ and the observations from which they were derived left nothing to be desired for the general case, but to estimate the hourly discharge during the rapid oscillations of the river some further refinement was found to be necessary both at Gamboa and at Bohio. At Alhajuela this was not required, because no measurements in the great floods of the river were there available, and the largest freshets were well represented by the formula.

For a great river like the Mississippi, where the general water level changes from month to month, and where consequently the rises start from very different levels at different seasons, the problem becomes complex; but for a river like the Chagres, which between freshets always subsides to a comparatively low and little varying level, advantage may be taken of the fact by grouping the freshets for separate study, and thus investigating the influence on the discharge exerted

by the rapidly varying local slopes, then so different from the condition in the great floods when, the whole channel being surcharged, the slope from hour to hour usually remains comparatively constant. This study was carefully made, the ample data permitting the selection of gaugings taken only at periods of rapid changes of water level, when the object sought, the mean line between the rising and falling branches, could be accurately recognized. Very many such freshets were studied both at Gamboa and Bohio; and not only was it found that accordant values resulted at each separate locality, but that they could be well represented by simply increasing in a nearly equal proportion the coefficients of the first power of the water-level term in the respective general formulæ. These special freshet formulæ, thus deduced, are the following, the variables having the same signification in these expressions as in the formulae given on page 339 preceding.

Gamboa, $Q=-26+40(C-13)+18(C-13)^2-0.5(C-13)^3$

Bohio, $Q=62C+5C^2+C^3$

In fine, the method adopted to determine the continuous discharge of the Chagres since January, 1898, and for previous dates when the bi-hourly fluviograph readings are at hand, has been the following:—When the river is at a stand, or changes its level gradually, the above general formulæ are used, or rather the rating tables derived from them. When a freshet occurs and the stream begins to rise rapidly, the special formula table takes its place until the original level is approximately regained—reference being made to any actual gaugings available, in case of uncertainty as to which formula should be used, an uncertainty which in practice hardly occurs, so pronounced are the changes of level in the Chagres. If space permitted the reproduction of the very numerous tables of daily discharge at the three most important localities in the valley, each value based on wholly independent data, their uniform conformity to the known conditions would leave no doubt as to their accuracy. Indeed, on one occasion a small clerical error in the tabulated bi-hourly fluviograph readings at Gamboa was detected from the resulting discrepancies in discharge as compared with that at Alhajuela and Bohio. The daily average values at the three posts are thus shown by internal evidence to be relatively correct and any absolute uncertainty, due to the use of the coefficient eight-tenths in reducing the original gaugings, must affect them equally. As such error, if any exists, lies on the side of safety, the figures may certainly be accepted for purposes of canal regulation. Few hydraulic data are better established.

As will appear later, the continuous discharge for as long a period as possible is an important element in the problem. The mean monthly values are given, in the second table of the Appendix,* for the thirteen years which have elapsed since the work passed from the control of the old company. In compiling it, preference has always been given to determinations by fluviograph readings and the rating tables; but when, in the earlier years, some gaps exist in these records, they have been supplied by averaging the actual gaugings. It may be added that a comparison of the two methods covering many months has demonstrated that the causes of error in the latter largely balance each other in practice, and that important discrepancies are rare. To supply some gaps in the first four years at Bohio, and a few in the earlier months at Alhajuela, use has been made of the well determined ratios to transfer discharges measured at Gamboa—ratios which will be discussed below. Finally as no other method of interpolation is available, the only missing mean monthly discharges, those at Gamboa in January, 1890, and those at all three posts in May, 1902, are supplied by the mean of the other twelve years.

It is believed that this table presents a trustworthy estimate of the volumes delivered by the Chagres during this long period; but it should be remembered that evidence has been offered above tending to show that the river recently has been passing through a period of minimum flow, and that the annual volume would probably be increased if it had been possible to include all the years since work on the canal began.

Great Floods of the Chagres.—Only five great floods have occurred since the canal operations were inaugurated, and the records of the Panama railroad show that no damages to the road occurred prior to the first of these floods, in 1879. These records cover half a century. The exceptional character of these occurrences and the little probability of frequent interference with canal traffic are therefore demonstrated. When floods do occur, however, they are sufficiently formidable to demand well considered measures of regulation, and accordingly all the existing records have received elaborate study.

It is to Gamboa that attention is chiefly attracted, not only because the river first attains the canal at that point but also because more data have been collected there than at any other single point. The bi-hourly discharges there are shown in Figure 2. The different floods will be treated in turn, beginning with the last and following back in order of date.

* See page 368, this issue.

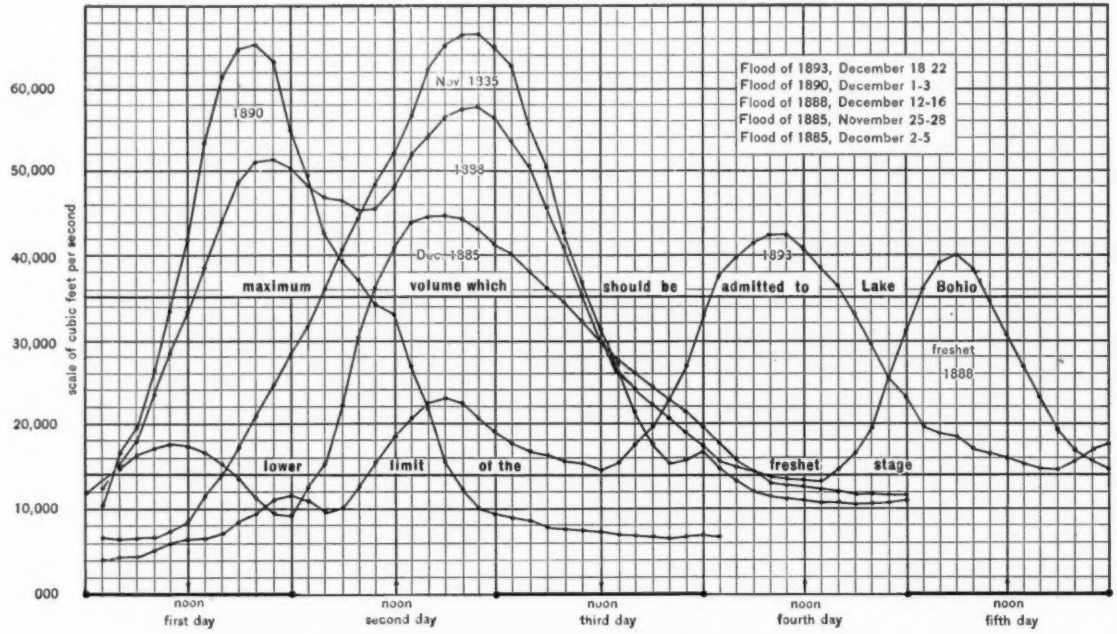


FIG. 2. BI-HOURLY DISCHARGES OF THE CHAGRES IN ITS GREAT FLOODS.

Flood of 1893.—This flood was carefully measured, and although it was the least formidable of any it merits special attention. After moderate showers on the 14, 15, and 16 of December, a heavy rainfall began on the evening of the 17 and continued until the 24. During these seven days 13.9 inches of rain fell at Gamboa, and 13.2 inches at Panama. The daily record at Colon was 1.02, 3.35, 4.64, 4.36, 3.47, 2.44, and 1.06 inches, making a total of 20.34 inches. The wind, shifting from south to west and northwest, blew in squalls and heavy gusts forcing the storm clouds over the entire Isthmus. The inundation caused but little damage. The current attained a velocity of from 8 to 10 feet per second, and brought down a few drift logs, and deposited some fine sand a short distance above Buena Vista.

The curve marked 1893 on Figure 2 exhibits the bi-hourly water levels and discharges by rating table at Gamboa during this flood. Fifteen actual measurements were made, and the following figures are added to illustrate how accurately the estimate by rating table and fluviograph represents the river. The discrepancy is only about 3 per cent., and that on the safe side.

Date 1893	Hour.	Height above sea, metres.	Discharge in feet seconds. Measured.	Tabular.	Difference.	Remarks.
Dec. 19.....	8:15 a. m.	17.32	12,714	13,173	—459	
do.	9:00 a. m.	17.52	13,420	14,223	—813	
do.	10:30 a. m.	17.94	14,833	16,669	—1,836	
do.	4:40 p. m.	18.94	23,380	22,850	+530	
Dec. 20.....	8:45 a. m.	17.79	15,857	15,751	+106	
Dec. 21.....	9:50 a. m.	21.52	35,757	35,939	—182	
do.	4:30 p. m.	20.52	28,465	33,904	—5,439	River falling rapidly.
Dec. 22.....	11:00 a. m.	17.86	16,387	16,175	+212	
do.	3:20 p. m.	17.63	14,409	14,868	—459	
Dec. 23.....	7:35 a. m.	17.05	11,619	11,760	—141	
do.	3.50 p. m.	17.22	12,679	12,643	+36	
Dec. 24.....	10:40 a. m.	16.67	9,853	9,853	000	
do.	3.10 p. m.	16.31	7,805	8,193	—388	
Dec. 25.....	8:10 a. m.	15.89	7,452	6,392	+1,060	
do.	2:45 p. m.	15.81	7,063	6,075	+988	
Means ...			15,446	15,899	—453	

It is shown by Figure 2 that the flood presented itself in three waves, of which the first and last were ordinary freshets, but that the intermediate rise attained at Gamboa at 9 a. m. on December 21 a level of 25.33 feet above low water, with a maximum volume of 43,086 cubic feet per second. The largest discharge in 48 hours occurred between 10 p. m. of December 20 and 10 p. m. of December 22, being 27,971 cubic feet per second, or 65 per cent. of the maximum. This percentage has an important bearing upon the problem of regulation, as will appear later.

The river in floods receives important contributions from the tributaries intermediate between Gamboa and Bohio, 20 miles below. Moreover the low lands of Tavernilla, between Bohio and San Pablo, are always inundated at such times, and this exerts an important regulating effect on the wave which reaches Bohio, reducing its height and prolonging its flow. These modifying influences in the flood of 1893 nearly masked the three waves and united them in one. The highest level attained at Bohio was reached at midnight on December 21, being 28.54 feet above low water with a maximum discharge of 51,100 cubic feet per second. The largest volume in 48 hours passed at the same time as at Gamboa, and was 43,590 cubic feet per second, or 85 per cent. of the maximum. To avoid confusion, the curves at Bohio are not shown on Figure 2.

Flood of 1890.—This flood was of a quite different type from that of 1893. The river at Gamboa rose with unexampled rapidity about 25 feet in 17 hours, and immediately subsided about 21 feet in 23 hours. These figures at Bohio were 19 feet in 31 hours and 11 feet in 14 hours. This is the most sudden and violent oscillation of the Chagres of which there are records, and it places in a strong light the exaggerations which have been current. The Senate Committee on Interoceanic Canals was informed under oath in February, 1902, that a rise "as high as 52 feet in 2 hours" was reported.

This flood was naturally more destructive than that of 1893. In the morning of December 1 the river began to rise rapidly, carrying huge drift logs and waifs of every description. At 9 p. m. it reached the flooring and swept away part of the bridge near Gorgona, wrecked a dredge, and did other damage. Railroad communication had already been interrupted between Matachin and Gorgona by 5 feet of water on the rails; it soon stood about 1.5 feet deep on the line between Bohio and Barbacoas and between Lion Hill and Gatun; and by 2 a. m. of December 2 it had invaded the line between Frijoles and Tavernilla. Traffic was restored on December 3 by the rapid fall of the river.

The highest level was reached at Gamboa at 8 p. m. on December 1, being 31.82 feet above low water; at Bohio it was reached at 1 p. m. of December 2 and remained unchanged for three hours, being 32.15 above low water. The corresponding discharges were 65,371 and 71,660 cubic feet per second. The largest average discharge in 48 hours at Gamboa occurred between 2 a. m. of December 1 and 2 a. m. of December 3, and was 34,752 cubic feet per second, or 54 per cent. of the maximum; at Bohio it occurred between noon of December 1

and noon of December 3, and was 51,068 cubic feet per second, or 71 per cent. of the maximum. Bi-hourly details are shown on Figure 2.

Only one actual gauging was made at Gamboa during this flood, at about 4 p. m. on December 2, indicating a discharge of 14,303 cubic feet per second, the river being 13 feet above low water. By fluviograph and rating table the volume was 19,636 cubic feet, the difference being explained by the fact that the river was falling rapidly. At Bohio two gaugings were made, at 7 a. m. and at 1 p. m., December 2, the river being 30.8 feet and 32.15 feet above low water. The corresponding discharges were 64,877 and 75,048 cubic feet per second. The volumes by the fluviograph and rating table were 65,512 and 71,657 cubic feet.

Flood of 1888.—This flood, although it attained a less height by about 6 inches than that of 1890, was more formidable by reason of its long duration. The rise at Gamboa began on December 11 from a level only about 2 feet above low water, mounted rapidly about 22 feet, subsided slightly only to resume its upward movement, attained its highest point 31.37 feet above low water at 9 p. m. on December 13, subsided gradually for about 48 hours, and then after developing into a large freshet finally fell on December 17 below the 10-foot stage, which marks the lower limit of ordinary rises. It had remained above this stage for 128 hours. There were other freshets of moderate height but of unusual duration in this month, giving a record of 424 hours above the 10-foot stage, or more than double that of any other month in the 20 years of which we have records. December, 1888, would doubtless have tested any system of river regulation more severely than any other in the last half-century except November, 1879. Unfortunately no fluviograph record is available at Bohio. The extreme height there was about 34.68 feet above low water, indicating a discharge of 79,000 cubic feet per second.

At Gamboa the maximum discharge was 58,132 cubic feet per second; the largest in 48 hours, occurring between noon of the 12 and noon of the 14, was 48,278 cubic feet, or 83 per cent. of the maximum, the largest percentage noted. Bi-hourly details of the flood will be found on Figure 2, including those of the freshet which followed so closely on December 15-16 as to be not without importance in connection with the problem of regulation.

It may be remarked here that the distinction between the so-called freshets of the Chagres and its great floods is based not only on the extreme height attained but also on the duration. The floods result from heavy rainfalls in the basin, lasting for several days, while

freshets follow much shorter downpours. In the latter, the high stage of the river seldom continues for more than 24 hours, and the average discharge in that period has been adopted as the standard for comparing them. This freshet of December 15-16 was one of the largest of them, giving the average discharge at Gamboa of 28,289 cubic feet per second for 24 hours. That of May 16-17, 1897, gave 30,549 cubic feet; that of November 27-28, 1901, gave 25,357 cubic feet. They are liable to occur in any month except February and March. Two of them occurred even in January, in 1902, giving discharges for 24 hours of 22,532 and 16,811 cubic feet per second. Such volumes, as will appear further on, are considered too large to be permitted to enter a route traversed by ocean steamers.

The inundation caused by the flood of 1888 was extensive. Communication by rail was interrupted for 24 hours or more between Matachin and Gorgona, between Frijoles and Tavernilla, between Bohio and Barbacoas, and between Lion Hill and Gatun. A dredge was swept away and one of the crew was drowned. Injuries were done to the canal between kilometre points 16 and 22, and other damages were reported.

Flood of 1885.—This flood also presented peculiar features. The rise at Gamboa began on November 25 from a level about 6.5 feet above low water, mounted steadily for 36 hours to the maximum height, 31.50 feet above low water, then "after a few moments" subsided rapidly nearly to the 10-foot level, there oscillated for 5 days, and finally on December 3-5 developed into a second flood smaller than the first but quite comparable at Gamboa with that of 1893. This was the first flood to occur after work had begun on the canal, and some attempts at measuring the discharge were made, but a diligent search among the old documents has failed to discover details as to methods of gauging or of reduction. An approximate rating table was made, which at some levels compares well with later studies. The fluviograph register has enabled the flood at Gamboa to be analyzed with precision, but unfortunately no records at Bohio are available.

The highest point was reached at Gamboa at 8 p. m. on November 26, with a discharge of 64,488 cubic feet per second. The greatest average for 48 hours, between 8 p. m. of November 25 and 8 p. m. of November 27, was 43,404 cubic feet, giving a ratio of 67 per cent. of the maximum. The second flood reached its highest level, 24.11 feet above low water, at from 4 to 6 p. m. on December 3, with a discharge of 44,923 cubic feet per second. The greatest average for 48 hours, between 5 a. m. of December 3 and 5 a. m. of December 5, was 32,421

cubic feet per second, giving a ratio of 72 per cent. The greatest heights attained at Bohio in these two rises were approximately 33.79 feet and 26.41 feet above low water, indicating discharges of 74,800 and 47,466 cubic feet per second.

Flood of 1879.—Abundant evidence exists to establish that this flood considerably exceeded any one of later date, and hence that any safe plan of regulation must take it into account. It occurred in November, when a violent rain storm with strong northerly winds prevailed for six days over the entire Isthmus. The only rain record was kept at Panama, where 12.6 inches fell; but this fact warrants no conclusion as to what fell in the valley of the Chagres, where precipitation is always much larger and is often double the amount at Panama. The river data are also meagre. An investigation of water levels was confided, shortly after the occurrence of the flood of 1888, to M. Sosa, a Colombian engineer of high repute who had been educated in the United States, and who subsequently became a member of the *Comité Technique*. He assured me personally that the evidence collected left no doubt that the volume carried in 1879 must have been much larger than in any later flood. The following figures exhibit his determinations of relative level in what are unquestionably the two greatest known floods of the river. They give the height in feet above mean tide of the highest water levels.

	Flood of 1879.	Flood of 1888.	Difference.
At Buena Vista.....	43.96	39.96	4.00
At Bohio.....	39.37	34.68	4.69
Difference	4.59	5.28	0.69

Another examination made shortly after the flood of 1888 near San Pablo, where the railroad bridge at Barbacoas afforded a trustworthy point of reference, went to prove that there too the flood of 1879 reached a point "higher than in 1888 but not very much higher."

It has been suggested, in the desire to reduce the cost of the regulating works, that the extensive excavations made by the old canal company between 1879 and 1888 may have lowered the water level in the latter flood, and thus have suggested an exaggerated idea as to the relative volume carried in the former. The facts do not warrant this claim. The excavations near and above Bohio did not sensibly increase the direct channel way in that region, being oblique to and at a considerable distance from the direct route of flow. Near the site of the dam the natural channel of the river is contracted and sweeps round a sharp bend of more than 90 degrees, creating an obstruction that in floods must oppose much resistance and be the dominating obstacle to the flow. This obstacle was the same in both floods. Below Bohio

considerable excavations had been made, and if they had tended to lower the water level their effect should have been much more apparent at Bohio, below the gorge, than at Buena Vista a mile and a half above. But the records just quoted indicate that the fall in water surface between Buena Vista and Bohio in the two floods was so nearly identical as to render the large difference in absolute level between them inexplicable upon any other supposition than that of a much larger volume passing in 1879 than in 1888. Moreover, as a matter of fact, in both floods the whole region below Bohio was deeply inundated, and in so enormous a waterway an increase of 2,500 square feet, largely estimated, could not have materially lowered the general level. On the contrary, the cuttings across the natural bends in the lower river may have caused in 1888 whirls and cross currents tending even to raise it. It is clear that the only conservative estimate to be formed of the maximum momentary discharge at Bohio in the flood of 1879, is that to be derived from the recorded water level 39.37 feet above zero; and this by the rating table is shown to be 112,730 cubic feet per second.

Unfortunately no water levels in this flood were secured at Gamboa, but the fact that the oscillations in this lower part of the basin are quite similar justifies the following computation, based on the comparative levels attained in the other four floods. The table gives the extreme heights above mean sea level in metres, and the figures below indicate the calculations to deduce the probable height at Gamboa. The probable levels at Bohio in the flood of 1885 are deduced in a similar manner.

Locality	1879	Nov., 1885	Dec., 1885	1888	1890	1893
Gamboa	25.17?	23.60	21.35	23.56	23.70	21.72
Buena Vista....	13.40	....	....	12.18	....	....
Bohio	12.00	10.30?	8.05?	10.57	9.80	8.70

$$23.56 + (12.00 - 10.57) = 24.99$$
$$23.56 + (13.40 - 12.18) = 24.78$$
$$23.70 + (12.00 - 9.80) = 25.90$$
$$21.72 + (12.00 - 8.70) = 25.02$$

Resulting height..... 25.17 ± 0.17 metres.

In other words, the extreme height of the flood of 1879 at Gamboa was 36.65 feet above low water, with a probable error of about 6 inches. This would indicate a maximum momentary discharge of 78,614 cubic feet per second.

Regulation of the Floods.—No one will claim that such floods as those just described can be allowed to enter a ship canal. Since the idea of a sea-level construction has been dropped by common consent, it would be useless to discuss the practicability of diverting such vol-

umes into separate channels. The problem then resolves itself into determining what part of them should be held back temporarily, and where the reservoir lake or lakes should be located, when resort is had to the familiar method of slack-water navigation. The following summary of results already reached will be found convenient for reference. It will be remembered that low water at Bohio is taken as 0 metres, and at Gamboa as 14.0 metres above mean sea level.

Flood.	At Gamboa.				At Bohio.			
	Max. height ft. above l. w.	Discharge in ft. sec. Maximum.	In 48 hrs.	Per cent.	Max. height ft. above l. w.	Discharge in ft. sec. Maximum.	In 48 hrs.	Per cent.
1893	25.33	43,086	27,971	65	28.54	51,100	43,590	85
1890	31.82	65,371	34,752	54	32.15	71,660	51,068	71
1888	31.37	58,132	48,278	83	34.68	79,000	?	?
Nov., 1885	31.50	64,488	43,404	67	33.79	74,800	?	?
Dec., 1885	24.11	44,923	32,421	72	26.41	47,466	?	?
1879	36.65	78,614	?	?	39.37	112,730	?	?

The facts known relative to the great floods warrant the belief that at Gamboa the period of danger may safely be estimated at 48 hours, and that the percentage of the maximum volume which passed in that period in 1879 may safely be taken at that measured in the similar flood of 1888, which was 83 per cent. These figures give for the total volume to be dealt with at Gamboa, in the greatest of known floods, a discharge of 65,250 cubic feet per second for 48 hours, or a total volume of 206,000 acre feet.

At Bohio the problem is more complex, by reason of considerable contributions from the intermediate tributaries, and of the reserved volumes held back by the flooded areas, which have always tended to reduce the maximum discharge and to prolong the duration of dangerous flow. Moreover fewer measured percentages are available there than at Gamboa, and those that are known rule higher, as is natural. Furthermore, the lowest practicable location for a dam is found at Bohio, and this introduces the question of what volume may safely be allowed to pass to the region below in these great floods. For these reasons a different mode of estimating the duration of danger at this point seems to be desirable.

Observations of present conditions and of the capacity of the channels to be provided below Bohio, satisfied the *Comité Technique* that about 42,000 cubic feet per second could be allowed to leave the artificial lake and pass thence independently to the sea, without causing serious overflow or otherwise interfering with the service of the canal. What especially calls for study, therefore, is the duration of the period in which the river at Bohio delivered a volume greater than this in

each of the unknown floods, by noting what occurred in the two for which data have been preserved. This estimate may be made upon various suppositions, but the most logical and conservative appears to be that the duration in question was proportional to the relative maximum heights reached in the floods to be compared. This simply assumes that the hourly curve of rise and fall near the dangerous period in the unknown flood was essentially parallel to that observed in the known flood.

Applying this method to the floods of 1893 and 1890, it will be found from the tables of hourly flow that in the former the discharge equalled or exceeded 42,000 cubic feet per second between the hours of 10 a. m. on December 21 and 1 p. m. on December 22, a period of 27 hours; and in the latter between the hours of 7 p. m. on December 1 and 3 a. m. on December 3, a period of 32 hours,—the intermediate average discharges being 47,400 and 60,300 cubic feet per second. The extreme heights attained above low water and the corresponding maximum discharges are given in the last table. It remains to make use of these data for estimating the volumes which passed below Bohio in the four unknown floods by comparing each of them in turn with the two known floods as a standard.

STANDARD, THE FLOOD OF 1893 (47,400 FT. SEC. FOR 27 HOURS).

Flood of 1888... $\frac{47{,}400}{51{,}100} \times 79{,}000 = 73{,}320$ ft. sec. for $\frac{34.7}{28.5} \times 27 = 32.9$ hours

Flood Nov., 1885 $\frac{47{,}400}{51{,}100} \times 74{,}800 = 69{,}420$ ft. sec. for $\frac{33.8}{28.5} \times 27 = 32.0$ hours

Flood Dec., 1885 $\frac{47{,}400}{51{,}100} \times 47{,}466 = 44{,}100$ ft. sec. for $\frac{26.4}{28.5} \times 27 = 25.0$ hours

Flood of 1879... $\frac{47{,}400}{51{,}100} \times 112{,}730 = 104{,}600$ ft. sec. for $\frac{39.4}{28.5} \times 27 = 37.3$ hours

STANDARD, THE FLOOD OF 1890 (60,300 FT. SEC. FOR 32 HOURS).

Flood of 1888... $\frac{60{,}300}{71{,}660} \times 79{,}000 = 66{,}460$ ft. sec. for $\frac{34.7}{32.1} \times 32 = 34.6$ hours

Flood Nov., 1885 $\frac{60{,}300}{71{,}660} \times 74{,}800 = 62{,}900$ ft. sec. for $\frac{33.8}{32.1} \times 32 = 33.7$ hours

Flood Dec., 1885 $\frac{60{,}300}{71{,}660} \times 47{,}466 = 39{,}940$ ft. sec. for $\frac{26.4}{32.1} \times 32 = 26.3$ hours

Flood of 1879... $\frac{60{,}300}{71{,}660} \times 112{,}730 = 94{,}800$ ft. sec. for $\frac{39.4}{32.1} \times 32 = 39.3$ hours

In order to compare these results it is only needful to reduce them to a common unit, for example, the number of acre feet of water which should be impounded in the reservoir or reservoirs above Bohio in order to protect the canal and region below against inundation. This is done by deducting 42,000 from each of the above discharges, multiplying the remainders by the corresponding hours reduced to seconds, and dividing the product by 43,560 (the number of square feet in an acre). Performing these operations the following values for the needful capacity will be found:

Flood of 1893 (actually measured).....	12,100 acre-feet
Flood of 1890 (actually measured).....	48,400 acre-feet
Flood of 1888 (compared with 1893).....	85,100 acre-feet
Flood of 1888 (compared with 1890).....	69,900 acre-feet
Flood Nov., 1885 (compared with 1893).....	72,600 acre-feet
Flood Nov., 1885 (compared with 1890).....	58,200 acre-feet
Flood Dec., 1885 (compared with 1893).....	4,330 acre-feet
Flood Dec., 1885 (compared with 1890).....	Nothing
Flood of 1879 (compared with 1893).....	193,200 acre-feet
Flood of 1879 (compared with 1890).....	171,400 acre-feet

These figures confirm what all the known facts and records tend to establish; to wit, that the flood of 1879 so much exceeded any other that it is a safe, and the only safe, standard upon which to base plans for regulation. In adopting definite figures, the indications based on the flood of 1893 should have preference, for although that of 1890 much exceeded it in violence, the exceptional suddenness of its rise and fall and its comparative short duration would make it an unsafe dependence. The flood of December 1885 has never heretofore been submitted to analysis, and the above figures demonstrate that at Bohio it had no importance; the volume, as will appear further on, proceeded chiefly from the upper Chagres, receiving but small contributions from the tributaries below Gamboa, but at that point it was sufficiently formidable to be worthy of consideration.

The precise reservoir capacity to be provided above Bohio is too important an element to be lightly treated, or to admit of an underestimate without incurring risks of serious calamities. It was the unanimous opinion of the *Comité Technique* that the flood of 1879, supplemented as to duration by the data secured in 1893, should form the basis of the projet. Furthermore, bearing in mind that the use of the ratio eight-tenths in reducing the gaugings (adopted to avoid any possible over-estimate of low-water supply) entails a safety coefficient for flood volumes, it was agreed unanimously to adopt 250,000,000 cubic metres (about 203,000 acre feet) as the total reservoir capacity demanded above Bohio. Such a reserve will protect the entire

valley occupied jointly by the river and canal against overflow, provided a safe system of regulating the volume allowed to escape from lake Bohio is furnished. The latter can easily be effected by adopting the Stoney overflow weir (or some similar device) which has given perfect satisfaction on the Manchester Ship Canal, and which being operated at the lake itself will be controlled from what can be seen on the spot. Excellent outlets are available, well separated from the dams and locks and leaving nothing to be desired. The problem in Nicaragua would have been far more complex, as the overflow would have been at the dam itself, and the proper rate would have been wholly dependent on the conditions existing at the lake situated fifty miles away.

It remains to consider whether a single lake or two of them would furnish the best solution of the Panama problem. A dam at Bohio creating a lake extending at least to the point where the canal leaves the river near Gamboa is manifestly demanded. Should this lake receive dimensions sufficient to retain the entire volume, including that required for evaporation, infiltration, the generation of power, and the supply for canal lockages in the dry season? The objections to such a plan were found to be numerous and weighty.

The canal from the Atlantic coast to Bohio is projected at sea-level. A good location for two locks in flight is found near the best location for the dam at Bohio. It was considered desirable to limit the lifts to about 9 metres each, or say 30 feet. This would indicate, as the highest flood level of the lake, a height above mean tide of about 20 metres (66 feet). Elaborate surveys of the region above, to be flooded, showed that its surface would then cover about 5,500 hectares (13,592 acres) affording a capacity to store only about 150,000,000 cubic metres (121,600 acre feet). If then this lake were to be the only one in which to store the entire reserves, as well for canal operation and wastage as for flood regulation, its surface must be very considerably raised above the desired level, entailing locks with excessive lifts, as the site is not well adapted for three in flight. But this would not be the most objectionable feature in so considerably raising the desired lake level. At the site of the dam the river traverses a rocky gorge where a tertiary deposit of gravel and sand underlies at a considerable depth the present bed, but is itself overlaid by a thick stratum of sandy and compact clay furnishing a foundation well suited to an earthen dam to be subjected to a head not exceeding about 70 feet. To increase the pressure considerably might possibly cause infiltration through the underlying materials that would permit the escape of an

undue portion of the canal reserves, and thus lead to waste and depletion of the volumes stored to meet the needs of the low-water season.

But these manifest difficulties at and below Bohio were by no means the only reasons for adopting a plan with two reservoir lakes. A single lake would allow the Chagres to strike the canal with its full force near Gamboa, not only in the occasional great floods but also in the freshets frequently occurring throughout eight months of the year. They often attain a momentary discharge of 25,000 to 35,000 cubic feet per second and bring down a moderate amount of sand and gravel, the latter of which has occasionally supplied ballast for the railroad. The entrance to the lake for 4 or 5 miles above Tavernilla is contracted and objectionable currents with frequent dredging at this locality would interfere more or less with the use of the canal by shipping. In a word, the Chagres should be regulated at its entrance into the transit route as well as in its lower course.

Nature has favored the plan with two lakes. An excellent dam site exists at Alhajuela, about 9 or 10 miles above in direct line, where the surveys have demonstrated that ample reserves may be stored for all the needs of the canal in the dry season, and for a flood reserve of 150,000,000 cubic metres (121,600 acre feet) to be held back and delivered gradually, as desired, after the flood has ceased. With such an upper lake there will be, of course, no difficulty in regulating the volume to be admitted to lake Bohio in ordinary freshets, even to the extent of giving a practically uniform flow to the stream. For these several reasons the *Comité Technique* was unanimously of opinion that the double-lake plan should have the preference.

It remains to consider how the 250,000,000 cubic metres constituting the total flood reserve should be divided between the two lakes. Occurring so rarely as do the great floods, it would appear that a volume of 1,000 cubic metres per second (35,000 cubic feet) may be permitted at such times to enter lake Bohio, giving in the contracted portion near Gamboa a velocity of about 1.6 miles per hour. Adopting this figure, the reserve to be held back at Alhajuela may be computed upon the same principles that have been applied above at Bohio. The conclusions will be even more definite, since all the floods except that of 1879 were actually measured at Gamboa. The following is the computation to make known the reservoir capacity that would have been required at Alhajuela to restrict the maximum volume allowed to enter lake Bohio in each of the great floods to the quantity of 35,000 cubic feet per second.

STANDARD, THE FLOOD OF 1893 (39,378 FT. SEC. FOR 16 HOURS).

$$\text{Flood of 1879....} \quad \frac{39{,}378}{43{,}086} \times 78{,}614 = 71{,}850 \text{ ft. sec. for } \frac{36.65}{25.33} \times 16 = 23.16 \text{ hours}$$

STANDARD, THE FLOOD OF 1890 (50,291 FT. SEC. FOR 23 HOURS).

$$\text{Flood of 1879....} \quad \frac{50{,}291}{65{,}371} \times 78{,}614 = 60{,}480 \text{ ft. sec. for } \frac{36.65}{31.82} \times 23 = 26.50 \text{ hours}$$

STANDARD, THE FLOOD OF 1888 (48,947 FT. SEC. FOR 45 HOURS).

$$\text{Flood of 1879....} \quad \frac{48{,}947}{58{,}132} \times 78{,}614 = 66{,}190 \text{ ft. sec. for } \frac{36.65}{31.37} \times 45 = 52.57 \text{ hours}$$

STANDARD, THE FLOOD OF NOV., 1885 (51,456 FT. SEC. FOR 31 HOURS).

$$\text{Flood of 1879....} \quad \frac{51{,}456}{64{,}488} \times 78{,}614 = 62{,}730 \text{ ft. sec. for } \frac{36.65}{31.50} \times 31 = 36.03 \text{ hours}$$

STANDARD, THE FLOOD OF DEC., 1885 (40,826 FT. SEC. FOR 24 HOURS).

$$\text{Flood of 1879....} \quad \frac{40{,}826}{44{,}923} \times 78{,}614 = 71{,}460 \text{ ft. sec. for } \frac{36.65}{24.11} \times 24 = 36.48 \text{ hours}$$

Reducing, as before, to a common unit for comparison:

Flood of 1893	(actually measured).....	5,790 acre feet
Flood of 1890	(actually measured).....	29,050 acre feet
Flood of 1888	(actually measured).....	51,880 acre feet
Flood of Nov., 1885	(actually measured).....	42,140 acre feet
Flood of Dec., 1885	(actually measured).....	11,560 acre feet
Flood of 1879	(compared with 1893).....	70,500 acre feet
ditto	(compared with 1890).....	55,800 acre feet
"	(compared with 1888).....	135,500 acre feet
"	(compared with Nov., 1885).....	82,700 acre feet
"	(compared with Dec., 1885).....	109,600 acre feet

These figures would seem to leave no doubt, if for no other reason than to guard against annoying currents, gravel and sand deposits, and delays in canal operation at the contracted entrance to Lake Bohio, that the lake at Alhajuela should be regarded as an essential element of the regulation of the Chagres. It should provide for the temporary storage of about 150,000,000 cubic metres (121,600 acre feet), leaving the remaining 100,000,000 cubic metres (81,100 acre feet) to be held back in Lake Bohio. This was the plan proposed by the engineers of the New Company in the low-level projet.

These flood reserves have been questioned, in *Le Génie Civil*, as perhaps needlessly large, because based on the estimated requirements of the flood of 1879 concerning which existing data are defective; and the idea has been advanced that the flood of 1888 might better have been adopted as the standard. The chief point of uncertainty at Bohio is the probable duration of excessive discharge, which neither in the flood of 1879 nor in that of 1888 is of record. It will be noted from the

above figures that at Gamboa, where several floods are well understood, the conclusions as to their relative importance reached by the study at Bohio are amply confirmed. In an element of so great importance as flood regulation in a route to be traversed by the commerce of the world, any error should lie on the side of safety. Furthermore, the unexampled duration of high water at Gamboa in the month of December, 1888, (424 hours above the lower limit of freshets) suggests that if more complete data even for that month were available the requirements estimated above based on what occurred in the 45 hours of greatest flow might be increased. What is certain is that in both the floods of 1879 and 1888 the river exhibited powers of offense not judiciously to be underrated.

In fine, by the projet adopted by the New Panama Canal Company the entire river is regulated. Neither in the great floods nor in the frequent freshets will the passage of the largest ships be retarded at the entrance of the lake near Gamboa; locks of moderate lift will afford ready access to it at Bohio; and the volume allowed to escape to the region below will not exceed what can readily pass through separate channels to the sea without in any degree encroaching upon the canal. Incidentally, the difficulties in the construction of a dam at Bohio will be very greatly reduced, as compared with any single-lake projet, and, as will appear below, the low-water reserve will be secured against any possible danger of reduction by undue infiltration. Such are the merits of the double-lake plan of regulation.

Ratio between Downfall and Drainage.—Before considering the matter of water supply for the canal during the season of low water, it seems desirable to refer to a criticism which has been raised against dependence upon artificial lakes in which to store such reserves.

In the Additional Report of the Senate Committee on Interoceanic Canals dated January 7, 1901, appears the following statement:

> "We cannot know in advance what an artificial lake can supply to meet the emergencies of the dry season in a torrid country where the bottom of the basin is left in its natural condition and may be inadequate to retain the waters impounded in it, and this problem cannot be determined except by long experience. In this case no effort has been made to solve this vital question; it is left entirely to conjecture. As this is a factor in the problem on which the entire question of a water supply depends, the absence of any practical effort to solve it is conclusive against its adoption."

The writer of this paragraph was ill informed. The problem had been carefully considered by the engineers of the New Company, and a preliminary study of the results of the investigation had appeared in a Government publication which was issued in the United States in June, 1900.

It is clear, in the case of any artificial reservoir, that without actually flooding the region in question dependence must be placed on one or both of two lines of research—the nature of the geological formation, and a comparison between the volume of water received from the clouds and that flowing to the sea by the watercourses. In the case of the Chagres valley, the geological examinations gave every promise that the water impounded would be retained with even less infiltration than usual; but, following their habit of neglecting nothing which could throw light upon the problem, the engineers of the New Company instituted what is perhaps the most elaborate study of the ratio between downfall and drainage that has yet been made in a valley like that of the Chagres above Bohio. The results, set forth in the following facts and figures, leave no doubt that the subsoil is fully saturated with water, and that no open route exists for any considerable subterranean escape.

The character of the general basin above Bohio, and of its three subdivisions, has already been described, and it only remains to consider the element of area entering the problem. The best map extant is one combining the surveys made for the Panama railroad with those for the canal, and covering the entire region with sufficient accuracy to define the dividing line separating it from the exterior watercourses except for a distance of about 35 miles on the northern and eastern portions of the upper basin. Here the limiting crest has never been traced, but a reconnaissance of the Chagres branch above its junction with the Pequeni made by a party of the Isthmian Canal Commission coming from the San Blas region, the notes of which were courteously communicated to the New Company, has enabled this gap to be approximately filled. Any error resulting from uncertainty as to the exact limits of this small portion of the boundary of the entire watershed can affect the computed ratios only so slightly as to have no influence on any general conclusions resulting from the study.

To determine the rainfall in the basin, daily observations have been made at Bohio, Gamboa, and Alhajuela, while those of the Panama Railroad at Colon may fairly be considered to represent what falls in the extreme upper part of the sub-basin, which so closely approaches the Atlantic coast as to be subjected to similar conditions. The following table exhibits the dimensions of the region in question. They indicate that it is not a violent assumption to consider that the average monthly rainfall in the lower sub-basin is measured by the mean of that noted at Bohio and Gamboa; that of the middle sub-basin, by the mean of that noted at Gamboa and Alhajuela; and that of

the upper sub-basin, by the mean of the rain fall noted at Alhajuela and at Colon.

Sub-basins.	Basin of the Chagres above Bohio. Area in square miles.	Per cent.	Approx. length, miles.	Approx. width, miles.	Length of bed, miles.	Number of affluents.
Above Alhajuela.....	320	46	18	16	31	?
Alhajuela-Gamboa	130	18	7	18	11	15
Gamboa-Bohio	250	36	11	23	20	17
Totals.....	700	100			70	

The general formula for computing the desired ratio for the entire basin, based upon the above assumptions and data, is the following, that for each sub-basin being easily derived therefrom. In it Q denotes the discharge in cubic metres per second at Bohio; D, the number of days considered; B, G, A, and C the corresponding rainfall at Bohio, Gamboa, Alhajuela and Colon, expressed in metres; and R the desired ratio for the days considered. The numerical coefficient of the denominator correlates the mile and metre units.

$$R = \frac{Q \times 3600 \times 24 \times D}{1610^2 \left(\frac{250(B+G)}{2} + \frac{130(G+A)}{2} + \frac{320(A+C)}{2} \right)}$$

For convenience the computations have been made for calendar months, which in general afford periods sufficiently long to eliminate errors resulting from the time elapsed between the precipitation and the outflow from the basin, which, as will appear below, varies in freshets from 24 to 48 hours. The manner of determining the bi-hourly discharges from which the values of Q result has been fully described above. It should be noted that the first rainfall observations at Alhajuela were made in June, 1899, and therefore that for earlier months it has been necessary to adopt the rainfall at Colon for the average in the upper sub-basin, modifying the formula accordingly. Comparisons of results thus computed with those of the later months when the rainfall at Alhajuela is known, have demonstrated that any errors induced in the desired ratio are very much too small to affect conclusions based on the general study.

Data have been collected to permit this investigation to cover the entire basin, the lower sub-basin, and the two upper sub-basins jointly, for a period of about five years; and to do the same but differentiating between the upper and middle sub-basins for four years. The numerical values of the ratio between downfall and drainage, thus computed, are presented for each month, except for May, 1902, when through a misunderstanding the observations were suspended.

Month.	Above Bohio (5 years).						Above Gamboa (5 years).					
	1898	1899	1900	1901	1902	Mns.	1898	1899	1900	1901	1902	Mns.
Jan.	1.79	0.99	1.00	3.28	1.10	1.63	3.83	1.50	1.35	4.29	0.82	2.36
Feb.	6.33	0.67	7.13	2.50	6.89	4.70	14.52	5.36	11.12	3.98	8.96	8.79
March ..	1.72	0.97	3.50	0.81	1.04	1.61	3.33	1.88	3.06	0.77	1.59	2.13
April ...	0.75	1.66	0.39	0.53	0.54	0.77	1.48	2.83	0.50	0.60	0.83	1.25
May	0.47	0.32	0.29	0.30	...	0.35	0.70	0.49	0.33	0.39	...	0.48
June	0.48	0.55	0.30	0.42	0.70	0.49	0.12	0.96	0.33	0.43	0.90	0.55
July	0.48	0.41	0.54	0.47	0.47	0.47	0.29	0.42	0.48	0.64	0.58	0.48
Aug.	0.44	0.81	0.71	0.43	0.59	0.60	0.68	0.95	0.72	0.48	0.89	0.74
Sept. ...	0.66	0.58	0.59	0.64	0.59	0.61	0.88	0.66	0.57	0.67	0.69	0.69
Oct.	0.65	0.63	0.79	0.59		0.67	0.88	0.70	0.82	0.54		0.74
Nov.	0.84	0.77	0.65	0.83		0.77	0.96	0.79	0.65	0.67		0.77
Dec.	0.96	1.32	2.74	1.13		1.54	1.14	1.50	3.18	1.51		1.83

Month	Upper sub-basin.					Middle sub-basin.				
	1899	1900	1901	1902	Mns.	1899	1900	1901	1902	Mns.
Jan.	1.90	1.45	4.76	0.94	2.26	0.53	0.66	1.14	0.54	0.72
Feb.	0.67	13.42	4.43	8.75	6.82	0.21	*	*	9.94	5.07
March	2.35	3.23	0.95	2.15	2.17	0.72	*	*	0.79	0.76
April	3.32	0.81	0.80	1.17	1.52	1.64	*	*	0.13	0.89
May	0.51	0.43	0.51	...	0.48	0.25	*	0.14	...	0.13
June	0.99	0.37	0.52	0.87	0.69	0.36	0.23	0.28	0.79	0.42
July	0.41	0.43	0.79	0.52	0.54	0.50	0.62	0.22	0.81	0.54
August ...	0.95	0.74	0.58	1.10	0.84	0.80	0.67	0.22	0.47	0.54
Sept.	0.68	0.57	0.74	0.76	0.69	0.62	0.60	0.50	0.50	0.55
Oct.	0.71	0.78	0.57		0.69	0.59	0.91	0.46		0.62
Nov.	0.81	0.62	0.61		0.68	0.72	0.78	0.84		0.78
Dec.	1.49	3.13	2.13		2.25	1.51	3.57	0.16		1.75

* No outflow from basin.

Month.	Lower sub-basin.					
	1898	1899	1900	1901	1902	Means.
January	0.82	2.26	0.48	2.15	1.55	1.45
February	1.28	1.04	3.27	1.40	3.96	2.19
March	0.22	0.07	1.71	0.88	0.44	0.66
April	0.12	0.02	0.21	0.36	0.28	0.20
May	0.10	0.07	0.18	0.18	...	0.13
June	0.18	0.25	0.27	0.34	0.21	0.25
July	0.40	0.38	0.67	0.31	0.03	0.36
August	0.18	0.57	0.68	0.35	0.23	0.40
September	0.34	0.42	0.61	0.59	0.41	0.47
October	0.40	0.52	0.75	0.68		0.59
November	0.65	0.73	0.64	1.11		0.78
December	0.59	0.99	2.03	0.73		1.09

On Figure 3 is shown each of the annual monthly means and the general curve for the five years at Bohio; and an examination of the tables will demonstrate that the sub-basins confirm the same conclusions. The ratio between downfall and drainage is subject to a regular monthly variation. The smallest value, about four-tenths, occurs about the middle of May, at the end of the dry season, or shortly thereafter. The ratio steadily increases until by the middle of November it becomes about eight-tenths. During the dry season it varies greatly, as should be expected, often exceeding unity and attaining its

maximum value about February—demonstrating that at this season the greater part of the flow proceeds not from direct rainfall but from ground water. After February the supply begins to diminish, and the ratio falls rapidly to the minimum in May.

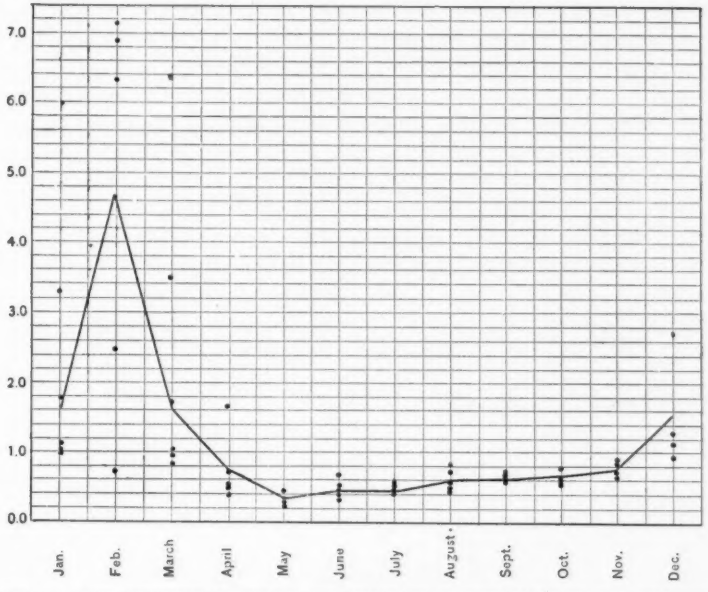


FIG. 3. RATIO BETWEEN DOWNFALL AND DRAINAGE IN THE BASIN OF THE CHAGRES ABOVE BOHIO.

Full line represents mean of five years' observations. Dots indicate annual means. Values above unity are explained by reception of ground water.

Although the variable nature of this ratio is well-known, depending on the character of the storms, whether violent or moderate, the condition of the soil as to geological formation and previous moisture, the nature and extent of the forest growth, and other local peculiarities, it is nevertheless not too much to assume that the concordant testimony of the entire valley and of its sub-divisions, shown by these figures, cannot be accidental but points to a general conclusion, to wit: the soil in this basin of the Chagres, covered with a dense tropical growth and subjected to sharply defined rainy and dry seasons, acts like a vast sponge to modify the flow of the river materially, and greatly to the advantage of the canal, since it causes a considerable discharge in the dry season. Further than this, the figures show that the

soil to heights much exceeding any projected for the artificial lakes is saturated with water which gradually percolates to the bed of the river, and hence that there can be no reasonable apprehension of loss by subterranean outlets.

These conclusions are so interesting that the study will be pushed further, not with a view to deduce precise figures but simply to illustrate in a general manner the scale on which nature is working. Let an average annual value for the ratio between downfall and drainage be assumed—say five-tenths, which experience has shown to be nearly that for streams of this size and character, and which the above measurements show to be applicable to the Chagres itself when receiving no considerable volume of ground water. Upon this assumption the portion of each monthly discharge attributable to direct rainfall may be computed, since it is the product of the measured monthly discharge by the quotient obtained by dividing 0.5 by the observed value of the ratio for the month. The difference between this quantity and the measured monthly discharge will represent the volume received from the ground. The results of such a calculation applied to the entire valley above Bohio for the four complete years covered by observations (1898-1901) are the following:

Month.	Measured ratio.	Measured discharge feet seconds.	Volume due to rainfall feet seconds.	Volume of ground water feet seconds.
January	1.76	3,284	918	2,366
February	4.16	1,377	176	1,201
March	1.50	883	283	600
April	0.83	1,095	671	424
May	0.35	2,154	2,154	000
June	0.44	3,037	3,037	000
July	0.48	4,838	4,838	000
August	0.60	5,156	4,309	847
September	0.62	4,521	3,638	883
October	0.67	5,827	4,344	1,483
November	0.77	8,264	5,474	2,790
December	1.54	3,708	2,013	1,695
Means		3,679	2,655	1,024

Without wishing to place too high an estimate upon the numerical accuracy of these figures, it may be noted that the only months (August and December) which fail to show a progressive and natural variation in the volume indicated for ground water were both affected by conditions tending to produce the discrepancies. Thus exceptional freshets in August, 1899, probably made the assumed annual ratio too small for that month; and the very exceptional low water in December, 1898, probably made it too high. However that may be, it seems to be a legitimate conclusion that a very large portion of the annual discharge

of the river, perhaps as much as one-fourth, and during the dry months even more than one-half, reached its bed as ground water. During the months of May, June, and July, or about three months after the rain had ceased, this supply was cut off, but only to begin again to filter through the springs and rivulets and gradually to increase until the maximum flow in November, December, and January. Such a regimen is certainly very fortunate for the canal, furnishing as it does a natural reserve to assist in supplying the needs of the dry season.

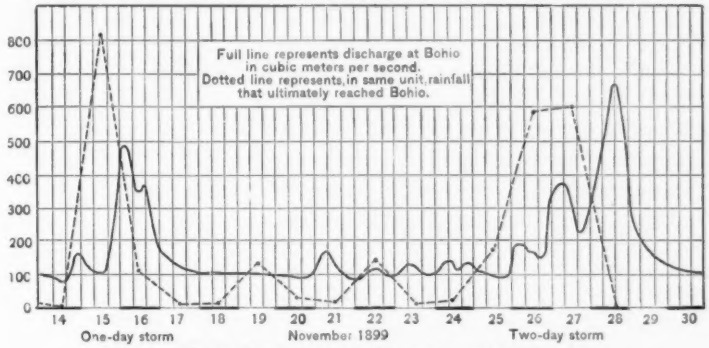


FIG. 4. RETARDATION OF RAINFALL BEFORE REACHING BOHIO.

Before leaving this subject of downfall and drainage it may be of interest to advert to another application which may be made of the analysis. Ignoring ground water, and assuming that the value of the ratio determined for each month is applicable to each day of it, it is easy to ascertain the time which elapses between the fall of the rain and its passage past Bohio in the bed of the river. By placing D in the last formula equal to unity, solving with respect to Q, and reducing, it may be put under the following form:

$$Q = 6750\ R\ (0.6\ B + 0.9\ G + A + 0.7\ C)$$

Substituting in the second member the measured mean value of R for the given month, and for each day the observed precipitation at the four stations in metres, the deduced daily values of Q will represent in cubic metres per second the volume of the daily rainfall that ultimately passed to the sea at Bohio. The sum of these volumes for the entire month will of course be identical with what was measured at Bohio. By platting each set of daily values and connecting them, the two curves will indicate to the eye the desired intervals of time between the fall from the clouds and the passage past Bohio.

With a view to obtain precise knowledge as to the interval of time of which use might be made, telegraphically, during critical periods in

the construction of the dam at Bohio, such a daily study was made during an entire rainy season, and the retardation proved to vary from 24 to 48 hours, according to the locus of the heaviest downfall in the basin. Figure 4 has been added to illustrate the method, which made very apparent the influence exerted by the longer or shorter duration of the storms. One or two days will cause a considerable freshet, but the great floods come only with long continued downpours.

Water Supply in the Dry Season.—A precise and well grounded estimate of the contributions of the river that can be made available to serve the needs of the canal, either directly or by storage in suitable reservoirs, is even more important than a knowledge of the volumes carried in the great floods. Any mistake here might be productive of consequences too serions to be contemplated. The demands of the three dry months, February, March, and April, need only be considered, as during the remaining nine months the supply is ample to meet any possible demands.

As may be seen by reference to the second table in the Appendix, this tri-monthly discharge of the Chagres at Alhajuela was determined in 1895, 1896, 1899, 1900, 1901, and 1902, with much precision; but as it is desirable to know not only the absolute minimum volume in seasons of minimum flow, but also to extend the inquiry to cover as many years as possible in order to estimate the average supply, it seems important to make use of the still more numerous gaugings at Gamboa and Bohio to throw additional light on the question. This may be done by noting the relative discharge at the three stations, especially in the dry season when the river is a quiet stream, rarely or never disturbed by freshets, and when, therefore, the desired ratio is subject only to small variations. This comparison has been carefully made with the following results, which are based upon monthly measurements for five years as between Alhajuela and Gamboa and Bohio, and eight years as between Gamboa and Bohio. It will be noted that the discrepancies caused by the three missing years at Alhajuela are insignificant, thus confirming the trustworthiness of the percentages.

Volume at Alhajuela 84 per cent. of that at Gamboa in dry season, 78 per cent. in rainy season, and 80 per cent. annually.

Volume at Alhajuela 75 per cent. of that at Bohio in dry season, 55 per cent. in rainy season, and 60 per cent. annually.

Volume at Gamboa 83 per cent. of that at Bohio in dry season, 68 per cent. in rainy season, and 72 per cent. annually.

The following table exhibits the application of these ratios to the problem in hand, the unit being cubic feet per second.

Year.	Measured tri monthly discharge.			Probable tri-monthly discharge at Alhajuela.		
	Alhajuela.	Gamboa.	Bohio.	84 per cent. of Gamboa.	75 per cent. of Bohio.	Means.
1890.....	....	1,165	1,427	978	1,069	1,024
1891.....	....	695	859	584	644	614
1892.....	....	1,377	1,672	1,156	1,254	1,205
1893.....	....	2,060	2,484	1,731	1,863	1,797
1894.....	....	1,107	1,224	930	918	924
1895.....	977	1,236	1,165	1,038	874	956
1896.....	973	1,038	1,377	871	1,033	952
1897.....	....	765	1,059	643	795	719
1898.....	....	1,448	1,601	1,217	1,201	1,209
1899.....	860	989	1,271	831	953	892
1900.....	636	636	836	534	627	580
1901.....	530	530	753	445	565	505
1902.....	1,259	1,519	1,836	1,276	1,377	1,326
Means....	871	1,112	1,351	941	1,013	977

These close accordances between the discharges actually measured at Alhajuela and those deduced from the gaugings at both Gamboa and Bohio can leave no doubt that the final column of means in this table may be accepted as indicating with all requisite precision the volumes that have passed Alhajuela in the dry season during the past thirteen years, and hence affords a trustworthy basis for estimating the shortage to be supplied by reserves in the reservoir lake. It appears that the minimum flow during the three dry months may safely be estimated as at least 500 cubic feet per second. The figure accepted in the estimates of the *Comité Technique*, adopted before 1901 (the year of minimum flow) was 16 cubic metres or 565 cubic feet. The volume usually delivered by the river will evidently be about 1,000 cubic feet.

In connection with the water supply another important element remains to be considered. It may be assumed that with the lapse of years the traffic will call for the daily passage of the largest number of vessels that can mechanically be accommodated—say twenty-four convoys moving in one or the other direction, having an average tonnage of 3,000 tons and serving the needs of an annual traffic of about 23,000,000 tons, which is nearly triple that of the Suez canal. Under such conditions will the portion of the annual volume carried by the Chagres and that can be conserved in the lake at Alhajuela then be adequate to meet the demands during the ninety days of the dry season, the natural flow of the river being ample at other times to meet all possible needs? This question involves not only the capacity that can be given to the projected lake, but also the volume which the river can be trusted to supply during the entire year. The latter element calls for a knowledge of the minimum quantity passing annually at

Alhajuela, which can be estimated from the records of the past twelve years by a computation similar to the above. The following table presents the figures in cubic feet per second.

Year.	Measured annual discharge.			Probable annual discharge at Alhajuela.		
	Alhajuela.	Gamboa.	Bohio.	80 per cent. of Gamboa.	60 per cent. of Bohio.	Means.
1890.....	....	4,175	6,088	3,340	3,653	3,437
1891.....	....	3,045	4,141	2,436	2,485	2,460
1892.....	....	4,314	6,257	3,451	3,754	3,603
1893.....	....	3,605	7,072	2,884	4,243	3,563
1894.....	....	3,773	6,098	3,018	3,659	3,338
1895.....	2,169	3,055	4,490	2,444	2,694	2,569
1896.....	2,107	2,743	4,214	2,194	2,528	2,361
1897.....	....	2,864	4,830	2,291	2,898	2,594
1898.....	....	2,979	3,943	2,383	2,366	2,374
1899.....	2,105	2,572	3,384	2,058	2,030	2,044
1900.....	1,836	2,345	3,508	1,876	2,105	1,990
1901.....	1,981	2,393	3,855	1,914	2,333	2,124
Means....	2,040	3,155	4,823	2,524	2,896	2,710

A comparison of the discharges actually measured at Alhajuela with those deduced from the gaugings at Gamboa shows a remarkable accordance, and certainly warrants the adoption of the values for the missing years as shown in the fifth column. The values deduced at Bohio, 20 miles below, although slightly larger, serve to confirm the same practical conclusions. The average annual discharge at Alhajuela considerably exceeds 2,000 cubic feet per second, and has never fallen below 1,800 cubic feet there since we have knowledge of the river. It remains to form an estimate of the volume of water required for the operation of the canal.

Two epochs will be considered: First, assuming the traffic which may be anticipated during the early years after the opening, say 10,000,000 tons, requiring the passage daily for 320 days annually of ten convoys moving in one or the other direction, each having an average tonnage of 3,000 tons; second, when the full capacity of the canal as projected is attained, calling for twenty-four such transits in one or the other direction, and yielding a traffic of about 23,000,000 tons.

Until the dimensions of the locks are finally fixed, which can hardly be considered the case at present, the computations must remain subject to revision; but, as will appear below, moderate changes in these dimensions will affect the total volume of water required in so small a percentage as to be negligible in a general study. For this reason it has appeared better to present the definite figures of the projet formulated by the *Comité Technique* rather than to introduce uncertain modifications. This projet was based on the probable commer-

cial requirements of the canal for the next fifty years, after extensive correspondence with leading shippers and ship-builders.

The volume of the lockages for a passage through the canal may be estimated from the general formula, applied to each slope, in which N denotes the largest number of locks in flight and V the corresponding largest water prism:

$$\text{Total lockages on slope} = \frac{N+2}{4} V$$

The other elements of the problem, all of which are independent of the traffic and nearly so of the dimensions of the locks, will be considered in turn. Evaporation at all exposed water surfaces was assumed at 6 millimetres (0.24 inches) per 24 hours. Loss by infiltration was allowed the same volume, although as has been shown above there is little probability of any important escape. The lighting of the canal, the manœuvres of lock gates, and the aid to shipping in the passage, are all to be effected by taking advantage of the artificial fall of about 46 metres (151 feet) at the dam at Alhajuela and at the locks at Bohio. In this manner about 4,300 horse power will be available, which by the agency of turbines and dynamos may be transferred electrically to the desired points of application with a loss not exceeding 50 per cent., thus furnishing an ample supply for all needs. The following table exhibits the continuous water flow per second required.

Requirements.	Traffic of 10,000,000 tons.		Traffic of 23,000,000 tons.	
	Cubic metres.	Cubic feet.	Cubic metres.	Cubic feet.
For lockages	10	353	24	848
For leakages at gates.....	3	106	3	106
Evaporation and infiltration.	5	167	5	177
False manœuvres	2	71	2	71
Lighting and motive power..	7	247	7	247
General contingencies	8	283	8	283
Total	35	1,237	49	1,732

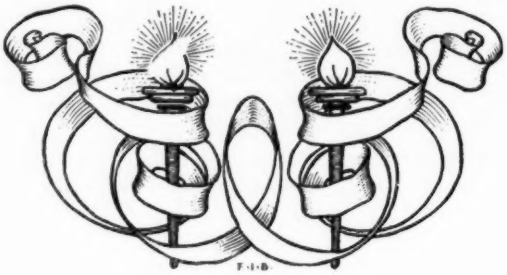
Deducting from these totals the volume which the river itself will contribute during the ninety days of lowest water, say 500 cubic feet per second, the needful storage capacity to be provided in the lake can readily be computed. The site at Alhajuela is exceptionally favorable, as will appear from the following summary of the projet of the New Company. The dam is to be of masonry, founded on and abutting against good rock. The following heights refer to mean sea level as zero: foundation, 19 metres or 62 feet; crest, 70 metres, or 230 feet; minimum lake level, 58 metres or 190 feet; level of low-water reserves, 65 metres or 213 feet; maximum lake level, 68 metres or 223

feet. These dimensions furnish a capacity for low-water reserves of 170,000,000 cubic metres (154,000 acre feet) and for flood reserves of 100,000,000 cubic metres (81,100 acre feet). Furthermore the dam is planned to admit of increased height, either at first or at any future time, permitting increased reserves at the rate of 30,000,000 cubic metres per metre of rise.

In fine, a comparison of these demands for low-water supply with the above tabulated statement showing the annual discharge of the Chagres at Alhajuela, will make apparent the fact that the river is marvelously well adapted to meet the needs of the canal. It supplies all the water that can ever be demanded by any probable traffic for centuries to come, and yet with judicious regulation no annoyance from currents will ever be experienced by shipping on any part of the route. Nothing better could be desired to subserve the object in view. Far from being a menace, the Chagres is a most useful friend.

The contrast is striking when a comparison is made with the conditions existing in Nicaragua where, for a distance greater than the whole length of the canal in Panama, shipping in transit must contend in the crooked San Juan river, swept by strong trade winds, with currents due to the entire drainage of a region 12,000 square miles in extent, where even the possibility of passage is dependent on skilful and accurate regulation of the level of a vast lake covering 3,000 square miles, for which no reserves can be provided, where the only outlet is 50 miles distant, and where the natural level is subject to considerable oscillations varying from month to month and from year to year. The question of water supply alone should be sufficient to decide the choice between the two routes. One is certain and sure; the other cannot but be subject to frequent and costly delays in transit.

The Appendices to General Abbot's paper will be found on the next two pages.



APPENDIX, TABLE 1.

NUMBER AND DURATION OF RISES AT GAMBOA EXCEEDING 10 FEET ABOVE LOW-WATER STAGE, THE GREATEST HEIGHT IN FEET ABOVE LOW WATER, AND LOCAL RAINFALL IN INCHES.

Year.	January.				February.				March.				April.			
	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.
1882..	..	..	...	...	..	..	...	...	..	..	...	0.5	..	..	...	1.5
1883..	0	0	7.3	...	0	0	2.3	...	0	0	2.0	...	0	0	3.1	2.6
1884..	0	0	5.7	...	0	0	3.3	0.7	0	0	2.4	0.3	2	9	12.6	6.5
1885..	0	0	3.3	0.2	0	0	3.1	0.2	0	0	2.9	0.0	0	0	3.9	1.4
1886..	0	0	7.3	0.5	0	0	4.8	1.1	1	9	12.8	0.7	0	0	8.2	2.8
1887..	0	0	8.2	2.2	0	0	4.9	0.1	0	0	3.9	0.3	0	0	3.6	6.8
1888..	0	0	5.1	0.1	0	0	3.3	0.6	0	0	3.0	0.4	1	10	13.1	1.3
1890..	0	0	9.1	4.1	0	0	less	0.3	0	0	less	2.4	0	0	6.3	3.0
1891..	0	0	less	0.6	0	0	less	0.0	0	0	less	0.3	0	0	less	2.1
1892..	0	0	less	1.1	0	0	less	0.7	0	0	less	2.6	0	0	less	4.7
1893..	0	0	3.0	0.7	0	0	3.6	1.1	0	0	6.3	0.7	2	27	16.3	7.4
1894..	2	25	17.9	1.5	0	0	2.2	0.2	0	0	1.0	0.1	0	0	2.4	1.3
1895..	1	2	10.3	...	0	0	2.4	...	0	0	2.3	...	1	1	10.0	...
1896..	0	0	4.9	...	0	0	less	...	0	0	less	...	0	0	8.5	...
1897..	0	0	7.2	...	0	0	less	0.2	0	0	less	0.3	1	3	10.2	3.2
1898..	2	22	17.0	2.8	0	0	2.0	0.1	0	0	1.6	0.0	1	10	17.7	1.4
1899..	2	29	14.2	5.0	0	0	less	1.7	0	0	less	1.3	0	0	5.3	1.4
1900..	0	0	8.9	1.0	0	0	1.4	0.2	0	0	0.2	0.1	0	0	6.3	3.2
1901..	0	0	3.2	0.4	0	0	2.4	0.2	0	0	1.0	0.2	0	0	2.3	0.8
1902..	3	57	16.4	13.4	0	0	2.2	0.2	0	0	0.9	4.4	1	5	11.2	9.5
Means	0.5	7	8.8	2.4	0	0	2.9	0.5	0.1	0.5	3.1	0.9	0.5	4	8.3	3.4

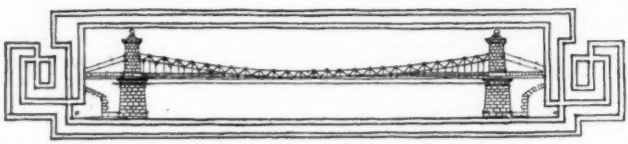
Year.	May.				June.				July.				August.			
	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.
1882..	..	..	...	15.5	..	..	...	6.3	..	..	...	10.1	..	..	...	9.9
1883..	1	10	16.7	9.7	2	14	14.1	11.0	4	37	16.7	6.5	5	43	13.8	15.9
1884..	3	137	16.1	6.2	5	29	16.7	13.4	4	49	17.7	9.6	3	25	15.1	16.5
1885..	0	0	5.9	11.1	1	2	10.2	10.4	6	41	16.4	9.1	8	66	18.0	15.5
1886..	0	0	9.5	15.7	2	10	11.8	10.6	5	31	15.1	11.7	5	28	11.8	16.4
1887..	6	54	16.1	11.0	11	108	24.0	19.5	3	21	15.4	14.0	11	130	16.4	19.2
1888..	0	0	8.2	20.5	6	43	14.8	11.9	0	0	less	3.3	1	7	12.2	10.2
1890..	5	44	13.8	13.3	4	26	13.1	11.7	4	34	14.8	10.4	7	45	13.1	15.4
1891..	2	15	14.1	7.5	1	10	14.8	9.3	2	18	16.1	6.1	0	0	less	8.5
1892..	7	49	17.4	16.8	1	6	12.1	8.5	8	65	16.7	14.0	3	28	16.1	14.3
1893..	2	23	16.4	11.9	0	0	5.9	10.7	1	5	11.8	15.9	2	13	13.9	8.0
1894..	1	5	10.9	10.9	0	0	6.9	8.8	4	26	13.8	10.1	2	9	11.8	8.4
1895..	0	0	2.3	...	1	12	15.9	...	1	13	13.7	...	2	6	12.9	...
1896..	..	..	...	3.4	..	..	...	3.3	..	..	...	5.8	..	..	...	...
1897..	6	96	23.0	17.4	0	0	8.9	12.6	0	0	9.7	9.1	..	..	...	17.2
1898..	0	0	7.5	5.3	0	0	8.6	4.7	1	7	12.6	18.4	2	6	10.3	20.1
1899..	2	15	13.5	8.5	1	2	10.1	8.8	1	1	10.1	9.5	2	23	16.2	11.0
1900..	0	0	9.1	6.8	0	0	7.5	12.2	2	12	11.6	13.4	3	16	13.5	8.9
1901..	1	8	13.4	10.9	1	1	10.1	7.7	0	0	8.2	9.2	2	5	10.3	13.9
1902..	..	..	...	...	0	0	6.4	6.3	1	1	10.1	6.3	1	10	15.1	8.3
Means	2.1	27	12.6	11.2	2	15	11.8	9.9	2.6	20	13.6	10.1	3.5	27	13.8	13.2

Year.	September.				October.				November.				December.			
	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.	Rises.	Hours.	Feet.	Rain.
1882..	..	..	...	11.8	..	..	...	8.2	8	104	18.4	11.8	0	0	less	1.4
1883..	4	53	14.1	4.1	1	2	10.2	10.0	1	10	11.8	7.0	3	32	15.4	6.3
1884..	3	21	13.8	10.5	5	42	15.4	22.4	2	31	19.0	6.2	0	0	6.9	2.2
1885..	7	67	18.0	16.1	6	54	11.8	9.3	2	52	31.5	13.2	7	155	23.9	11.0
1886..	5	48	15.1	9.1	9	92	15.4	13.6	13	156	17.1	16.1	4	72	15.8	4.6
1887..	2	55	23.3	11.5	..	..	...	14.9	4	154	18.7	24.1	2	127	15.4	12.7
1888..	10	78	15.4	12.3	5	27	12.5	9.6	3	20	10.5	16.2	4	424	31.4	16.3
1890..	3	27	16.1	8.9	5	49	17.4	21.4	3	30	16.1	9.9	3	53	31.8	4.3
1891..	0	0	less	10.5	1	1	10.2	15.7	2	54	19.7	10.7	2	18	12.8	6.4
1892..	0	0	6.9	13.7	2	17	13.1	11.1	1	30	22.8	10.2	2	74	15.8	6.6
1893..	0	0	9.2	10.2	0	0	8.9	16.5	1	9	13.1	13.9	6	170	25.3	20.9
1894..	3	20	13.9	15.2	3	19	12.5	15.3	5	35	14.1	10.7	7	149	19.0	8.3
1895..	0	0	8.9	...	2	22	17.1	...	0	0	8.5	...	1	1	10.0	...
1896..	..	..	...	...	..	..	...	...	..	..	...	...	1	15	13.3	...
1897..	..	..	...	18.8	1	2	10.2	12.8	3	16	12.7	5.9	4	37	13.2	8.6
1898..	0	0	5.6	4.1	2	13	13.7	8.7	3	25	16.9	14.6	0	0	4.5	2.4
1899..	0	0	8.6	13.5	0	0	9.8	8.0	2	16	14.8	8.7	0	0	9.4	2.7
1900..	1	4	11.2	9.3	3	24	15.1	12.1	2	14	11.9	10.7	1	14	14.1	0.8
1901..	1	6	11.7	8.4	0	0	9.5	14.1	7	73	20.9	19.1	1	14	15.4	6.7
1902..	..	..	...	...	..	..	...	...	..	..	...	...	..	.	...	...
Means	2.3	23	11.8	10.9	2.8	23	12.7	13.2	3.4	46	16.6	12.3	2.5	71	15.5	7.2

APPENDIX, TABLE 2.

MEAN MONTHLY DISCHARGE OF THE CHAGRES IN CUBIC FEET PER SECOND.

Month	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Mn.
						AT ALHAJUELA.								
Jan. ...	....	....	....	....	....	3214	2437	....	....	3178	1589	989	4238	2608
Feb. ...	....	....	....	....	....	1095	1059	....	....	848	812	671	1271	959
March .	....	....	....	....	....	742	600	....	....	848	530	459	812	605
April ..	....	....	....	....	....	1095	1271	....	....	883	565	459	1695	995
May ...	....	....	....	....	....	1483	2543	....	....	1589	1342	1554	1702	1702
June ..	....	....	....	....	....	2048	2225	....	....	2154	1554	1731	2190	1984
July ...	....	....	....	....	....	1801	2366	....	....	2225	2190	1978	2119	2113
Aug. ...	....	....	....	....	....	2543	2154	....	....	3284	2825	2437	2331	2596
Sept. ..	....	....	....	....	....	1907	2154	....	....	2402	2154	2931	2336	2320
Oct. ...	....	....	....	....	....	3638	2048	....	....	2649	3214	2755	....	2861
Nov. ...	....	....	....	....	....	2543	2472	....	....	2931	2967	4768	....	3136
Dec. ...	....	....	....	....	....	3920	3956	....	....	2260	2296	3037	....	3094
Means .	....	....	....	....	....	2169	2107	....	....	2105	1836	1981	....	2086
						AT GAMBOA.								
Jan. ...	2737	2048	1519	2296	3708	3532	2225	1766	4309	3496	1695	1024	5227	2737
Feb. ...	1342	954	1095	2013	1625	1483	1130	1130	1483	954	812	671	1589	1252
March .	1095	600	989	1236	954	1095	636	494	1024	954	530	459	1024	853
April ..	1060	530	2048	2931	742	1130	1342	671	1836	1059	565	459	1942	1255
May ...	4274	3461	5510	3037	1377	3461	4450	3284	2472	1907	1342	1766	3028	3028
June ..	5333	2366	3496	3214	2225	3178	4132	2366	2861	2472	1942	2048	2896	2964
July ...	5404	3779	7416	3567	4450	3073	2931	3779	4238	2825	3355	2190	3002	3847
Aug. ...	5686	2790	6074	4732	3885	4061	2331	4097	4132	4238	3567	2861	2790	3942
Sept. ..	6816	3037	4379	3885	4450	3390	2719	3850	2543	3178	3073	3638	2931	3684
Oct. ...	6499	4450	5933	3744	4697	4944	2684	3850	3461	3390	4520	3708	....	4323
Nov. ..	3956	7488	7240	4556	6533	3532	3214	4450	5192	3744	4061	6745	....	5059
Dec. ...	5898	4044	6075	8052	10630	3779	5121	4626	2296	2649	2684	3143	....	4916
Means .	4175	3045	4314	3605	3773	3055	2743	2864	2979	2572	2345	2393	....	3155
						AT BOHIO.								
Jan. ...	4253	2684	2225	3390	7063	4556	4732	2048	5651	3849	2119	1483	11231	4253
Feb. ...	1625	1377	1307	2437	1801	1377	1554	1589	1695	1731	1059	989	2084	1587
March .	1307	600	1236	1483	1095	1059	883	706	1095	989	742	706	1271	1013
April ..	1342	600	2472	3532	777	1059	1695	883	2013	1095	706	565	2154	1453
May ...	6286	2366	8087	4450	3355	4167	4944	7981	2684	2048	1625	2296	4191	4191
June ..	7840	3214	5156	4944	4273	4310	4203	4203	3355	3143	2860	2790	3178	4113
July ...	7946	4803	10913	7628	6216	4591	3143	5121	6569	3955	5615	3178	3073	5596
Aug. ..	8371	4520	8935	10772	6498	6922	3496	7275	5298	5721	5262	4309	3390	6213
Sept. ..	10030	4450	6428	7664	7452	5792	5933	6887	3214	4238	4768	5792	2931	5890
Oct. ...	9571	6534	8723	8582	9359	6922	6357	7487	5050	4944	6993	6322	....	7237
Nov. ..	5827	11019	10666	11443	12714	6074	7593	6057	7840	5297	6604	13244	....	8773
Dec. ...	8653	7522	8935	18541	12573	6957	6039	6816	2861	3602	3744	4591	....	7570
Means .	6088	4141	6257	7072	6098	4490	4214	4830	3943	3384	3508	3855	....	4824



FOUNDRY MANAGEMENT IN THE NEW CENTURY.

By Robert Buchanan.

I.—THE ECONOMICAL PRODUCTION OF CASTINGS.

With this article, Mr. Buchanan begins a systematic review of the best foundry practice which, in its complete extent, will survey the entire field of equipment and management. The paper in our next issue will consider "Crane Service for the Foundry Floor," with the aid of many illustrations of actual installations.—THE EDITORS.

IN the advance towards better and more exact methods of production which has marked the past few years, no branch of engineering has had less attention bestowed upon it than the foundry. Those who have had to do with foundries and with foundry work have long ceased to be impressed with the inconsistency in the measure of treatment and consideration extended to the foundry, as compared with that given to departments using the foundry products.

I believe this neglect does not proceed altogether from indifference to the provision of suitable conditions. It probably arises in part from the fact that the employers and heads of firms, themselves not being trained foundry men, are in doubt as to the best methods to adopt for the production of castings by means at once economical and productive of good working conditions for the men employed in the work. The innate conservatism of the men practically engaged in foundry work has had results confirmatory of the attitude of those holding control, and so the lamentable results of doubt in the governing body, on the one hand, and the leave-well-alone policy on the other, are visible in many works today.

The want of progress in methods of production and in the ideas governing methods of production must also be ascribed in great part to the class of men too often placed in charge of foundries. The foundry has been too often the dumping ground for the failures and incompetents for whom places had to be found somewhere. This was and is done, all forgetful of the fact that there is almost no position whatever in which ignorance of the business is so easily found out, or in which the interference of the untrained and incompetent can work such havoc and cause such loss, as in the foundry.

SECTION OF FOUNDRY OF THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

I have heard the managing director of a great engineering firm say that he made many improvements in the foundry of the company under his control by approaching the consideration of the matter with a mind unbiased by any previously formed ideas and prejudices, and that it was these same prejudices in the foundry people which had formed the greatest obstacles to the making of improvements. This is an instance of a keen intellect, sharpened by successful and effective control of other branches of engineering, making its impress upon the foundry by the very freshness of the ideas brought to bear upon the subject. Such an example is to be welcomed when accompanied by such powers, but the rarity of the example only serves to bring into greater prominence the necessity of applying to foundries the same rule of special training for the work which applies to all other branches of engineering.

It may be said that the conditions mentioned have arisen in the past, not from any desire to avoid employing men with foundry training in the most responsible positions, but for the reason that the supply of such men was inadequate to the demand. That there is ample room for improvement by those engaged in the business there is no gainsaying, though one may take leave to doubt, if, in the past, the rewards offered have been such as to induce the best class of men to

engage in the work. When we come to consider the foundry as if it were in itself a machine for the regular and economical production of castings, the necessity of special training for those having control of the machines will be apparent.

The foundry as it ought to be would be in many ways the antithesis of what in too many cases it is now. The present condition of many foundries is too hopeless a theme to warrant the waste of either words or regrets. Let us leave them to the benign influence of time, and to the decay which has marked them for its own.

In considering what a foundry ought to be, if it is to fulfil its function in the highest degree, the test to apply to any part of the whole is to question in how far each thing under consideration is lending its influence in the right direction for the cheap production of finished goods. Whether the foundry be selling to outside firms or is only a department of a works which absorbs the whole of the output, the value of the castings produced will be greatly enhanced or depreciated by the facility or otherwise with which they may be worked up into the finished machine.

The tendency is for firms using castings made in their own foundries to demand the production of a quality which lends itself to being economically and rapidly machined, rather than the saving of a few pence or shillings in the mixture of metal used. To foundries selling

CRANE ARRANGEMENT IN THE FOUNDRY OF LUDWIG LOEWE & CO., BERLIN.

to outside firms the cost of mixtures is of greater immediate moment, any advantage from easy machining not reaching the pockets of the foundry men, at least directly, as a result of savings in time, tools, and cutters. It is to be hoped, however, that good work in either case meets with its just reward. With the difference mentioned, both kinds of foundries may be considered as having the one end in view.

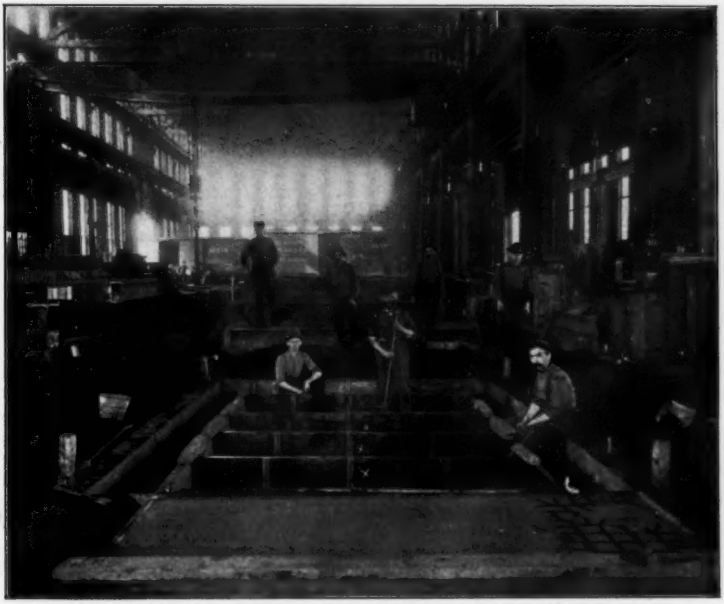
It is not my intention to set out an ideal foundry to be run by ideal people, but to consider as fully as is practicable some of the things which will be profitable to know—things which are of the most practical character. To set down in plan and elevation a foundry which would look very nice would not be difficult. That it would profit any one is doubtful. The requirements of each firm engaged in making

POURING FROM CRANE-CARRIED LADLES, FOUNDRY OF THE DEUTSCHE NILES WERKZEUGMASCHINEN FABRIK, BERLIN.

castings are so varied that we must content ourselves with a consideration of some of the component parts which help to make up the machine for producing castings which we call a foundry.

The class and volume of work to be done necessarily fixes the capacity and number of cranes in use. If loam castings are to be made, then the power of the cranes has to be considerably increased over

that which is necessary for green-sand or dry-sand castings. Per ton of castings made, loam moulds exceed in weight any others. When loam moulds are rammed in pits, as they usually are, they are lifted out after casting, the sand which has been used in ramming being only partially dug out. Such lifts add enormously to the crane power



PART OF SOUTH FOUNDRY, E. P. ALLIS WORKS OF ALLIS-CHALMERS COMPANY, SOUTH MILWAUKEE, WIS.

requisite, and so where loam castings are to be made a power of crane three times greater than the weight of the heaviest loam casting to be made is not too much.

I trust that it unnecessary to say much regarding the use of cranes occupying the middle of the foundry floor. Whether they be hand, steam, or hydraulic cranes, their position on the moulding floor is objectionable, as they occupy the most valuable space for moulding purposes. Round these floor cranes there is also found, almost invariably, a heterogeneous and unsightly collection of all the rubbish and dirt a foundry can produce.

The circles A and B (next page) represent the area covered by the ordinary floor crane. As in few of these can the blocks be brought nearer the centre than 5 feet, in each crane an area of at least 78 square

feet is absolutely lost for moulding. On the other hand, a heavy mould should have its centre not at the extreme distance the blocks will go towards the outer end of the jib. I have seen a not too-observant moulder forget that it is well to humour a crane by giving it vertical lifts to do. "Bedding in" a pattern a little out of the reach of the crane results in bad lifts, waste of time, and waster castings. When the moulds have to be cored all over, or have drawbacks on each side, then the furthest part of the mould must be easily within the radius of the crane. Only as auxiliaries to travelling cranes, and situated where they will give useful service with the occupation of least moulding space, are floor cranes admissible.

Next in importance to crane service is the question of situation of cupola, which depends of course upon the size of foundry to be served with metal.

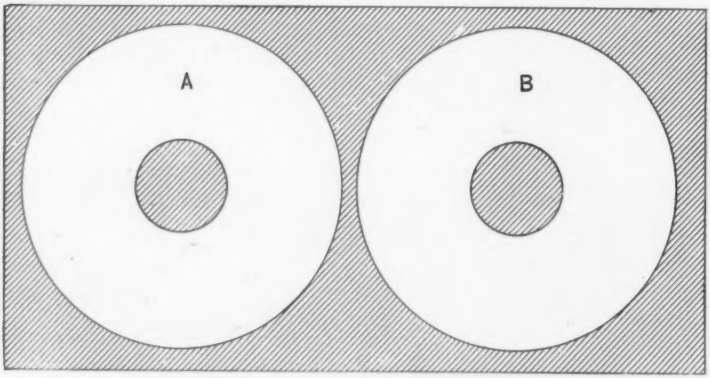


DIAGRAM ILLUSTRATING FAULTS OF CENTRE CRANES.
White area indicates portion served by cranes. Shaded portion is beyond their reach.

Foundries of sizes small to medium are best served if the foundry be an L in plan, having the cupola or cupolas in the inner angle. If the foundry be large and the work heavy to medium, then the best position for the cupolas is at the end of the main bays, the metal being conveyed along the bays by means of the travelling cranes.

A few foundries of very large area have the cupolas in the centre of the foundry, or as nearly equi-distant from all parts as it is possible to get. This is good if the work is all of a light character. The fluidity of metal required for thin or intricate castings is sure to be reflected in the cost of coke required for melting, if the distance over which the metal has to be carried is great. There are however obvious objections to centrally situated cupolas in foundries using crane ladles.

INTERIOR OF FOUNDRY, NILES TOOL WORKS, HAMILTON, OHIO.
View from front of cupola, which is situated at the head of the main bay.

ELECTRIC-CRANE ARRANGEMENT IN THE FOUNDRY OF THE YOUNGSTOWN STEEL CASTING COMPANY.
One four-motor 25-ton crane with 5-ton auxiliary hoist flanked by two 5-ton high-speed three-motor cranes. Designed to obviate delays of waiting for the cranes over a large foundry floor doing mixed light and heavy work. Northern Engineering Works, Detroit, Mich., U. S. A.

Wherever the cranes are, there must the cupolas be, and vice-versa. The cranes in such a case would be in the central bays, and as the largest castings would also be there, the transport of moulding materials and the castings themselves when made, place centrally situated cupolas at a disadvantage.

The cost of the distribution of melted metal is thus largely controlled by a suitable location of the cupola. Whether the metal be distributed by unskilled labour or by skilled labour, the cost of such distribution is inevitably reflected in the wages bill. Numbers of foundries have eliminated unskilled labour as far as it is possible to do so. It is quite possible to carry that too far and by doing so waste skilled labour in doing unskilled work. It is no more profitable to have skilled moulders wheeling sand or castings than it is to have a chief clerk copying letters. Each should be kept doing what he can do better than any one else, and the hewing of wood and drawing of water be left to those who can do that only.

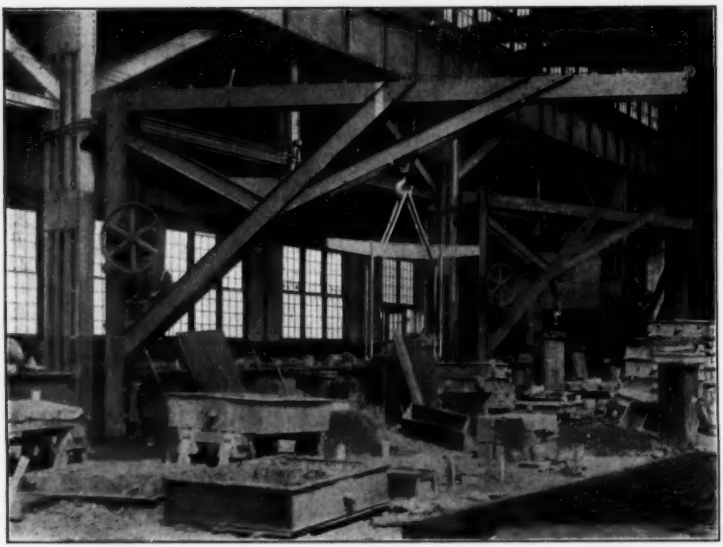
The supply of minor plant and tools is an important item in foundry operations. Some foundry people commit the great mistake of

AN OVERHEAD CRANE IN A BAY OF THE E. P. ALLIS WORKS SOUTH FOUNDRY.

20-TON TRAVELLING CRANE IN TEMPORARY FOUNDRY, BALDWIN LOCOMOTIVE WORKS.
Wm. Sellers & Co.

trying to carry on work with the smallest possible equipment of riddles, sieves, buckets, brushes, shovels, and other tools whose name is almost legion. The only thing these economists do not grudge is the time and money wasted because of this shortage. I know of a large foundry where the economy was so thorough that one moulder used a 56-pound weight with a recessed bottom as a "swab-pot," and it was not at all uncommon to see a moulder brush off the joint of his mould with his cap; the brushes were in the store and stayed there. The men were paid so much per hour, so they did not mind; if they had been on piece-work rates there would have been trouble. The economy in minor plant and wastage of time had a result not difficult to guess. Money was lost (fortunately by those with some to spare) and the presiding genius had to seek an outlet for his economical tendencies in another than the foundry business. It may be taken as a safe rule that no workman ought to have to wait one moment for another to be done using sieve, riddle, brush, or whatever it may be. Each moulder should have a complete outfit of tools for his own particular use, these tools having his check number branded on each. Any bad usage of tools is by this means avoided, as responsibility for their condition is immediate, and in flagrant cases punishable. As a

SPECIALISED FOUNDRY ARRANGEMENT.
Moulding machines, travelling table, and air hoist, Westinghouse Air-Brake Works, Wilmerding, Pa.



REMOVABLE JIB CRANES, FOUNDRY OF THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

THE WEST ALLIS FOUNDRY OF THE ALLIS-CHALMERS COMPANY. 60-TON TRAVELLING CRANE IN PROCESS OF ERECTION.

matter of fact, such a condition hardly ever arises, as the moulder has every inducement to keep his tools in the best order. Where tools are few in number and so have to be used by all and sundry, they get thrown about from one to another, and as no one in particular is responsible for them they last only half the time they ought to do. Under such conditions more tools per man are used than if each had a set for his own use. It is obvious that if a certain number of tools be used in doing a day's work by one man, they will last only half the time if used by two men, even if no bad usage ensues from the dual

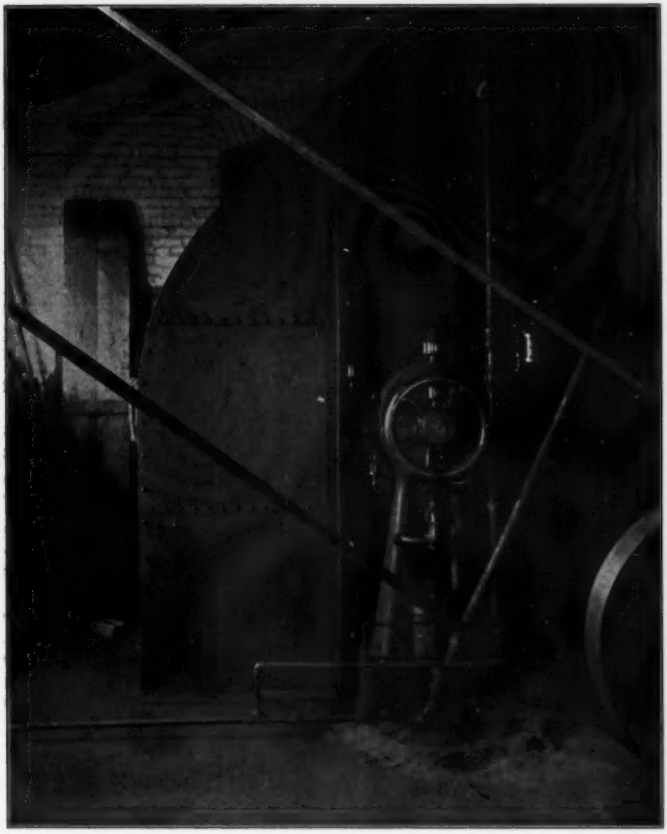
ownership. Where larger numbers use the same tools the length of service decreases in proportion, so that instead of economy of tools there is a greatly increased wastage, and the time lost in addition is enormous. How is it that shortage of tools is seldom seen in piece-work foundries, but often in those where the hands are paid time rates? Piece workers would not put up with the delays due to such shortage, but evidently the employers who pay time rates and allow a shortage of tools are not aware of what a fearfully bad bargain they make. There are foundries now, I do not hesitate to say, where each man, by loss of time in waiting, will waste as much time every fourteen working days, as would pay for a complete outfit of the tools he requires. Give a moulder all the tools he can use, hold him responsible for their proper and legitimate use, and if so used, the sooner he uses them up the better for the employer.

A want of system or order in the foundry greatly conduces to wastage of tools, whether the supply be ample or no. Each man should have his outfit of tools, and also a place to put them when not in use, and it ought to be seen that he uses the facilities given. Where there is a shortage of tools, eight to ten men having the use of one riddle, one sieve, one brush, etc., an orderly system may actually cause waste of time, strange as that may seem. Here is an actual case. A number of men had been given, for their joint use, one set of tools. A place was appointed for each riddle, etc., this being a nail or spike in the wall on which the article was to be hung when not in use. The penalty of not replacing the riddle, etc., after use was instant dismissal. There was no need to dismiss anyone for this cause. The man who worked, say, 20 feet away, replaced the tool in position when done with, although his neighbour was going to use it in two minutes. As all were being paid time rates, if the management saw fit to cause them to waste time walking back and forward instead of employing them more profitably, while not liking it, there was no particular reason why they should not obey orders. Such a system was really more wasteful of money than if the tools had been thrown about from one to another as each was required for use.

I could also mention the hiding of tools, which takes place where a limited number are available, thus making the number still more limited, but enough has been said to show that an ample supply of minor tools is anything but a minor question when considering the elimination of all conditions which hinder production, and so add to the cost of the product.

When we come to consider the atmospheric conditions which pre-

vail in most foundries we find a state of matters which would not be tolerated by either employer or employed in any other department. In the foundry it may be, and I admit is, difficult to have the air pure and free from draughts, and the difficulty is usually avoided by simply considering it and passing to some easier and more hopeful question.



VENTILATING FAN, FOUNDRY OF THE SANDY HILL IRON AND BRASS WORKS.

In winter the blower room can be closed against the outside air, drawing warmed air from within the works. Buffalo Forge Company's system.

It is unnecessary, I hope, to say anything regarding the influence of the surroundings or environment upon the physical and moral health of the worker, be he managing director, or the last boy recruit

brushing sand off castings in the dressing shop. The purer the air, the better the light, the more general comfort which prevails, the better will the results be in a material sense. It is no exaggeration to say that an examination of the cases of sickness amongst foundry workers will show that respiratory troubles form nine-tenths of the whole. These in great part arise from the conditions under which foundrymen work, and if not altogether to be avoided, can certainly be greatly improved.

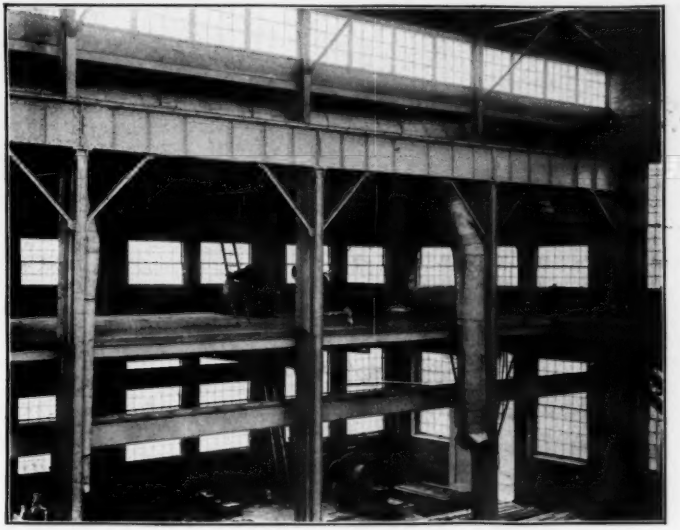
HEATING AND VENTILATING ARRANGEMENT IN FOUNDRY OF SANDY HILL IRON AND BRASS WORKS, SANDY HILL, N. Y.

The air from the blowers shown on the preceding page is thrown into the foundry through the pipes shown in the left foreground, the opening in the cupola-house wall, and other vents on the farther side of the charging floor.

What I would suggest here is the general use of fans at suitable openings in the foundry walls or gables, for the purpose of expelling the impure air and noxious gases, whether arising from pits, drying of ladles, or casting of moulds. Whether the fans be driven by a belt or by an electric motor, they should be such as may be put on or off at will. In the case of foundries having a constantly smoky atmosphere they would run almost constantly, but in the greater number of foundries, with such a condition only intermittent, then the fan would be used only as required.

That foundries require warming will be a surprise to many. It is true, nevertheless, that more time is lost in the course of a year through

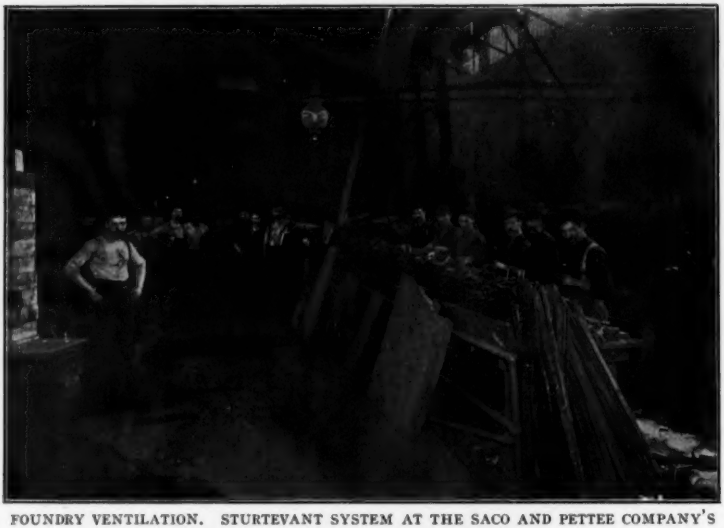
cold than through heat. In the United States, such is the extent of country, there are all sorts of climates and so the heating of foundries in winter is not universal because not necessary. In the northern states, and of course in Canada as well, heating the foundry in winter is an absolute necessity. In Great Britain the systematic heating of the foundry has been left severely alone, and in its place are to be seen a various assortment of fires upon the floor, combining quite successfully a maximum of smoke with a minimum of heat. It is a curious phenomenon that in winter it takes three times longer to get a core from the core stove than it does at any other season of the year!



THE NEW FOUNDRY OF THE CANADA FOUNDRY COMPANY (CANADIAN GENERAL ELECTRIC COMPANY), TORONTO.

Showing Sturtevant system of heating and ventilation applied to both the main foundry floor and the gallery. The air pipes are seen following the alternate pillars.

If the fuel which is burned in the fires mentioned were used in a system of heating by hot-water piping, or by hot air delivered into the foundry, the improved conditions would reflect themselves in increased output. There would be a much more equable temperature, attention to the numerous fires mentioned would be wholly obviated, and there would be less hanging around the core and other stoves, especially in the mornings. That much time is lost in the cold weather may be largely ascribed to the want of a proper system of heating.



FOUNDRY VENTILATION. STURTEVANT SYSTEM AT THE SACO AND PETTEE COMPANY'S FOUNDRY, NEWTON UPPER FALLS, MASS.
Warm fresh air enters through the pipes seen in the middle background, being forced in by blowers placed behind the wall.

Draughts in the foundry play a more important part than would be credited by one who has not experience of their effects. In winter the effects are principally upon the men, though I have seen a mould frozen by the cold air blowing through an open door. In summer the effect is upon the mould, drying it up and so prolonging the finishing.

The doors are in almost constant use, and in very many cases the large doors have to be opened wide on every occasion, as the designers of the foundry in the first place, and the carpenters in the second place, omit to put a small door by which individual workers may go out and in through the large door; the result is that the latter, being heavy and cumbersome, is left open all the time.

I have considered, as shortly as the importance of the subject will allow, some of the general conditions which should obtain in a foundry. Any one of these may be considered as of no great moment were it neglected, as, unfortunately, it too often is. We cannot afford to neglect the combined influence of the whole. Every stroke of the rammer, every grain of moulding sand used, has an influence upon the casting produced. So there should be made to converge upon production all the influence of suitable conditions, and by the elimination of all neutralising forces, good and economical working is assured.

COST-FINDING METHODS FOR MODERATE-SIZED SHOPS.

I.—THE SYSTEM OF THE BIGELOW COMPANY, OF NEW HAVEN.

By H. L. Arnold.

Mr. Arnold's article is the first of a group devoted to practical cost-keeping systems suited to a small shop or to a separate department of a large shop. Each of the papers will describe a method in actual daily use—one which has been studied out in the works, tested under practical conditions, and proved successful. Forms, blanks, etc., will be reproduced in full, and their use clearly explained. The shops have been selected to cover a wide range of mechanical work, and the writing of each paper has been committed to a competent expert in cost-keeping, to secure the utmost interest and value in the way of clear, discriminating, and critical exposition.—THE EDITORS.

THE cost-keeping methods of the Bigelow Company, manufacturers of boilers at New Haven, are taken as illustrative of a successful system for an establishment working about two hundred men, partly on inside work and partly outside. The system itself is the outcome of systematic and deliberate study—a construction rather than a growth.

The company is organized under a president, a general manager, who is present most of the time at the works, and a vice-president and sales manager in the New York office.

The works are divided into two general departments, the one known as the machine, pattern, and blacksmith shop, and the other as the boiler and sheet-iron shop; these are in charge of separate foremen. There are two separate tool rooms, one for the machine shop and one for the boiler shop, which are in charge of separate tool-room foremen.

The rough stores consist mainly of castings, rivets, plates, and stamped or formed plate details, as man-hole covers, pressed steel being now used in places where castings were formerly employed. The castings, which are mostly large, are all purchased outside, and are stored in the open yard adjacent to the departments where they are to be worked. The rivets go to the stores room opposite the office, and are in charge of a youth, who delivers them on verbal orders from the rivetting-gang bosses. He turns his memoranda over to the stock clerk, who is in charge of the rivet room and sheet stores, and delivers sheets to the layer-out, under directions from the boiler-shop super-

intendent. The superintendent's requisitions are based on the separate order specification received from customers, which are transmitted directly to the works and form the production orders. These orders are so varied that no production-order blank is used. Each order thus takes the form of a type-written specification, in general form similar to the one below.

COPIED. SEPT. 20, 1902. FACTORY NO.618

N.Y.ORD.3251.
THEIR ORD.37096.

RECEIVED
SEP 20 1902
BOILER SHOP

FOUR 6" SEPARATORS COMPLETE AS PER THEIR DRAWING NO.N.Y.-6020; TO BE 30 1/2" INSIDE DIAMETER AND 3 FT. 9" FROM CALKING EDGE TO CALKING EDGE; HEADS TO BE DISHED; ONE HEAD TO BE REVERSED; SHELL 7/16"; HEADS 1/2".

THE ABOVE MUST BE SHIPPED SO IT WILL ARRIVE AT DESTINATION BY JANUARY 1st, 1903.

SHIP TO ---

BLUE PRINT HAS BEEN SENT US SO WE CAN ORDER STOCK. AS SOON AS WE HAVE TAKEN THE NECESSARY MEMORANDUM FROM THIS FOR ORDERING THE STOCK WE ARE TO RETURN THE BLUE PRINT TO CUR N. Y. OFFICE AND IN A FEW DAYS THEY WILL SEND US OFFICIAL WORKING BLUE PRINT.

THE TYPE-WRITTEN PRODUCTION ORDER.

Every needful statement of requirement and condition, date of order and delivery date included, is, as will be observed, noted on this production order, so that the work can be intelligently brought out in the shops. Some of these individual-specification production orders are much longer than the one given; others are much shorter, calling perhaps for a number of rivets of a certain kind, or a piece of boiler plate punched and bent to certain specifications. All of these production orders are simply type-written sheets or slips, made either at the New York or New Haven offices of the works according to place of receiving them, and go directly to the department superintendents, without formalities or loss of time. If received in New York, the order bears a New York office order number, and each order is given a factory number, against which all production charges are entered. All orders are first copied in numerical sequence in the general factory-order copying-press book, kept in the main factory office, and two duplicate order copies are made, one being delivered to the cost clerk, who has an office with the boiler-shop superintendent on the ground floor adjoining the main boiler shop. He pastes all his copies in a

large book marked "Boiler-Shop Orders." The second duplicate goes to the superintendent of the machine shop, who has a similar book, lettered "Machine-Shop Orders," in which he pastes his full copy of each production order complete. The machine-shop superintendent and the boiler-shop superintendent and the cost keeper thus each have all particulars of each order, and each proceeds independently to bring out his individual portion of the structure demanded; in most cases the machine-shop work must and does, of course, precede the boiler-shop work.

All requisitions made by the machine-shop and boiler-shop superintendents on the rough-stores clerk have the order number, and the stores are delivered by the stores clerk and by him charged on his "Stores Delivered" book against the order numbers.

If a rough-stores order cannot be filled from stores in stock, the rough-stores clerk makes a proper order which goes through the main office to the outside source of supply. The rough-stores clerk examines the boiler-shop and machine-shop order books twice daily, morning and afternoon, and scrutinizes each order with care, and makes his requisitions on outside sources at once, so that the least possible delay intervenes between the receipt of a production order and the placing of needed material in the rough-stores room.

The tool-room charges are made against individual workmen on Form 1, reproduced in full. These forms are kept in alphabetically designated pigeon holes in racks in the two tool rooms, the same form serving for both. Charges are made by the tool-room keepers against the workman whose name heads the form, when tools are taken out, and cancelled by crossing off the charge when tools are returned in good order. Tools returned in bad condition are made the subject of inquiry if occasion demands, and may be charged to the workman if he is grossly in fault.

Flat-cost charges are made against production-order numbers on the boiler-shop and machine-shop detail-charges sheet, Form 2, enough sheets being numbered with each order number to contain all the charges against it. Form 2 is printed on both sides, and the back is in two forms, one for boilers, and one for machine and miscellaneous orders. These forms are filled by the cost clerk from the rough-stores book for the entries on the back, and finally, after both back and front sides are filled, they go to the bookkeeper, who enters the totals on the margins of the office order-book sheets where the original production orders are pasted. These blanks are then stamped "Charged" in large capitals, green ink, and are finally filed for future reference.

Name,..... Date,.....

No. of Pcs.									
	DRILLS AND SOCKETS.								
....	Drill Sockets,	Size.....			Kind.....				
....	" Chucks,	"			"				
....	Twist Drills,	Size,.....		Taper,.....		Straight,.....		Groove,.....	
....	Ratchet "	"		"		Square		"	
....	Flat "	"		"		"		"	
....	Counterbores	"		"		"		"	
	TAPS.								
....	Hand Taps,	Size,.....		Taper,.....		Straight,.....		Bottoming,.....	
....	Stay Bolt Taps,	"							
....	Pipe Taps,	"							
....	Special Taps,	"							
	PUNCHES AND DIES.								
....	Screw Punches,	Size,.....		Dies,.....		Punches.....			
....	Tube "	"		"		"			
....	Rivet "	"		"		.....			
	TUBE EXPANDERS AND TOOLS.								
....	Expanders,	Size,.....		Pins,.....		Rolls,.....			
....	Tube Cutters,	"							
....	" Reamers,	"		Cutters, ...					
	REAMERS.								
....	Pipe Reamers,	Size, ...							
....	Rivet "	"							
	WRENCHES.								
....	Monkey Wrenches,	Size,.....							
....	Open "	"							
....	Ratchet "	"							
....	Adjustable "	"							
....	Tap "	"							
....	Hack Saw	Blades,.....							
	HAND TOOLS.								
....	Snap Rivet Cupping Tools,	Size, ...							
....	Handle "	" "							
....	Hand Markers,	"							
....	Chisels, Cape	.....	Diamond Point, ...			Flat,.....			
....	Chipping Hammers,	.....							
....	Riveting "	.....							
....	Drift Pins,	.....							
	PNEUMATIC TOOLS.								
....	Engines,	.....	Piston, ...			Rotary,.....			
....	Hose,	.....	Length, ...						
....	Hammer,	.....	Calking Tools,.....						
....	"	.....	Beading Tools,.....						
....	"	.....	Stay Bolt Cups,.....						
....	Hydraulic Jacks,	Size, ...							
....	Chain Falls,	"							

FORM I. TOOL-ROOM CHARGE SHEET.

The original is more open, being 5 by 14 inches, heavy manila paper.

BOILER SHOP—FACTORY NO.

LAYING OUT	PUNCHING	PLANING	ROLLING	DRILLING			FITTING UP	RIVETING		BRACES	TUBES	CALKING	TESTING	HANDLING STOCK	LOADING & PAINTING
				HEADS	SHELL	NOZ. & FIG.		MACHINES	FLOOR						
				FLANGING											

PATTERN SHOP | **MACHINE SHOP** | **SMITH SHOP**

FRONT	BRACKETS NOZZLES	LOADING	HEADS	FRONT	NOZZLES FLANGES	PIPING	FEED	TAPPING	LOADING	BRACES	HANGERS	FRONT	ANCHORS ROLLS

FORM 2. FRONT. FILLED BY COST CLERK FROM WORKMEN'S TIME SHEETS.

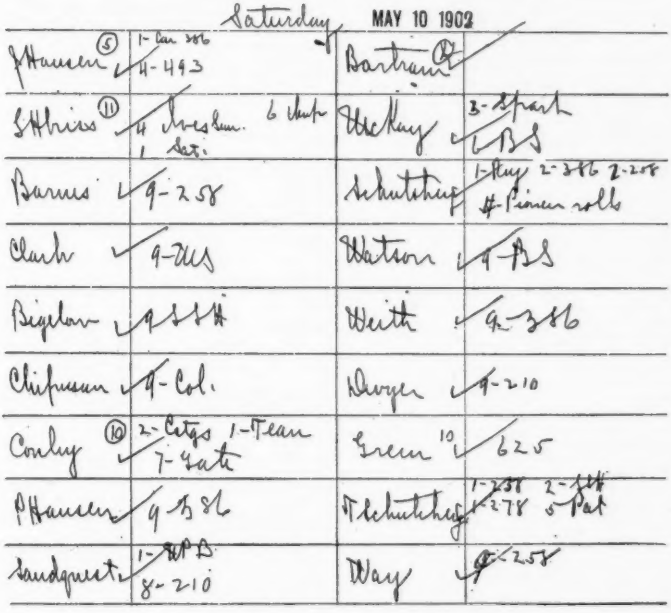
It will be noted that the various classes of work have different entry spaces. The form is printed in black on a stiff white card 9¾ by 5½ inches. The original has a few blank extra columns in each shop space, for special entries.

Plates in shell					
Straps					
Dome plates					
Dome heads					
Heads					
Barrel plates					
Fire box plates, inside					
Fire box plates, outside					
Top head					
Fire box head					
Reverse flange					
Rivets					
Stay bolts, solid					
Stay bolts, hollow					
Feet of _____ tubing					
Feet of _____ tubing, extra heavy					
Brackets, cast iron					
Nozzles " "					
Flanges " "					
Fronts " "					
Castings for setting					
Braces, bar iron					
Anchor bolts " "					
Hangers " "					
Front " "					
Front, angle iron					
Trimming					
Stiffeners					
Fusible plug					
Manhole plates					
Handhole "					
Sheet iron					
Angle "					
Feed pipe					
Bolts					
Fire brick					
Insurance					
Hours Boiler Shop					
" Machine Shop					
" Forging					
" Pattern Shop					
" Draughting					
Lumber etc. for loading					
Cartage					
Freight					

FORM 2. BACK OF WORKMEN'S TIME SHEET.

This is known as the "Regular" back, as it contains spaces for all regular charges agaiast horizontal or Manning vertical boilers. The "Special" form has no printed list, but is filled by entering the order. Weights or numbers are entered in the first vertical column, flat cost values in the second. Particular conditions or charges are noted in the horizontal lines at the top. The form, as noted under the copy of the front on page 389, is 5½ by 9¼ inches.

The workmen's time cards are in manuscript, written by the cost clerk, and by him filled from information gained by questioning individual workmen in the machine shop, from each individual smith's book kept by himself in the blacksmith shop, from the pattern-shop time book, which is made up by the cost keeper by individual questioning, and from the boiler-shop gang bosses, who keep slates or chalk-mark records of the one day. Every piece of stock takes the job number in white paint when delivered from the rough-stores room.



MACHINE-SHOP DAILY-TIME CARD.

A partial exhibit. The date is stamped in green ink, and the manuscript written daily by the cost clerk. Short-time and over-time entries are enclosed in circles. The boiler-shop time sheet is kept in the same way.

The smith-shop workmen's time is taken in the same way, the boiler-shop workmen's names lists and the smiths' names lists being written together daily, on large sheets, of sufficient size to contain all.

Outside work is recorded on two similar blanks, Form 3, 4⅜ inches by 6½ inches, grey and terra-cotta color, stiff cards. Both these cards are filled by the outside worker day by day, as he works, with both time and material charges, and both are signed by the fore-

F.H. & W.R.R. Sta. A.

Time Table, from *Feb: 7, 1901* **to** **190**

NAME.	MONDAY.		TUESDAY.		WEDNESDAY.		THURSDAY.		FRIDAY.		SATURDAY.		SUN-DAY	Traveling Time.	Total No. Hours.
	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.	Day	Night.	Day.	Night.			
Fidler							*5*	*13*	*10*	*9*					
Horsley								*10*	*10*	*9*					

I certify this Time Table to be corret.
Signed, *W E Harkness.*

FORM 3. OUTSIDE-WORK CARD, FRONT; AS FILLED AND VOUCHED BY CUSTOMER.

A stiff card, terra-cotta color, 6½ by 4½ inches. The back of the form is shown on page 393. A duplicate of this card, gray in color, and headed "Duplicate. Keep this Card to Compare with Bill," is left with the customer.

RULES AND DIRECTIONS

FOR

Charging and Filling Out Time Tables.

All men employed by us, when at work at any place outside of our works, are required to have their time written down on this table (on opposite side) and signed by the engineer or person in charge.

Nine hours—from 7 A. M. until 5 P. M., allowing one hour for dinner—constitutes a day's work, and will be charged as ten hours. No men sent out for less than two and one-half hours.

Time occupied in traveling both ways, between our works and the place where the work is performed, will be charged as single time.

When filling out the table for work done at Night, Sundays, or Legal Holidays, please state the number of hours worked, as two hours are allowed for each hour's work performed at such time.

Any expense incurred, such as traveling expenses, meals and board of men, will be charged to the parties for whom the work is done.

We pay our men and make our charges according to above rules.

THE BIGELOW CO.

BACK OF FORM 3—OUTSIDE-WORK CARD—BOTH THE GRAY CARD LEFT WITH CUSTOMER AND THE TERRA COTTA CARD VOUCHED BY CUSTOMER AND RETURNED TO THE BOOKKEEPER.

man or customer where the outside work is done. When the job is finished the grey card and the terra-cotta cards are thus duplicates, vouched by the outside authority signature. The terra-cotta card goes to the cost clerk and the bookkeeper, and the bookkeeper makes a bill therefrom to the customer. The grey card is left by the workman, on completion of the job, with the customer. As this card bears the customer's own voucher it cannot be disputed.

When the customer receives the bill he has only to compare the total charge of time and material with the duplicate in his possession. These outside-work blanks are printed on both sides. The back is printed with the workman's instructions, and the front is printed and filled as shown in the two reproductions given showing the customer's duplicate and the factory time card.

The items of "unproductive labor," which include every sort of work done, other than office and clerical work, not directly charged to any production order, are taken by the cost clerk daily, in his round through the shops, made when he fills his daily manuscript time sheet. The separate items are recorded in detail on a monthly-statement sheet of unproductive labor, which is turned in to the bookkeeper and by him is charged to expenses, divided into various charges against shop betterment, patterns, shop cleaning, and so on.

The shipping clerk besides attending to shipment details does some estimating; he looks out for the railway transportation, and is responsible for shipping details generally. Work ready for shipment is notified to him by department foremen on a "Ready for Shipment" card, white, 3 by 4 inches, stating that "Order No. —— is now ready for shipment," and signed by the foreman. The clerical force comprises a chief bookkeeper, shipping clerk, rough-stores keeper, with an assistant youth in charge of rivets, the cost keeper, and his assistant, also the stock clerk. The number of men in work varies from 175 to 200, as orders demand.

Almost the entire work of collecting and recording prime-cost items is performed by the cost keeper; his assistant, the stock clerk, has the receipt and delivery of stores in charge. The cost keeper is also the time taker, and rules and fills the manuscript time cards every day, and also handles the brass check board and workmen's brass individual checks, by which the entering and leaving times of the workmen are recorded, and does this work so easily as to have spared five hours in one day for giving the information here presented to the writer, without apparent inconvenience.

Each rivet order is filled in small excess of number, and from time

RACK	NO. OF PLATES	LENGTH	WIDTH	THICKNESS	FACTORY ORDER NO.

FORM 4. SHEET SHOWING DELIVERY TO WORKS ON PRODUCTION ORDERS.

The original is a stiff white card, 5 inches wide and 7 inches high, having 16 entry lines under the heading as shown. The plates are stored in racks, and the first column shows sheet-rack numbers.

to time the left-over rivets are collected in bulk and delivered to the youth in charge of the rivet bins, who sorts them into their individual places. The rivet shed stores the flanged work, one side being occupied by rivet bins and kegs, and the other side by flanged work, and pressed-steel man-hole plates.

In addition to the forms shown, there are two books of copied entries made up from the cost keeper's time sheets, one named "Machine-Shop Day Book," and the other "Boiler-Shop Day Book." These books are both written by the cost keeper daily, and these two day books are written by the bookkeeper into finished-product bills, made to purchasers. These day-book items are variously stamped in green ink by the cost keeper, "Outside Work, No Material," "Outside Work, Material Charged," as may be, in one right-hand column and the last entry on a given order is followed with a "Completed" stamp in green ink.

While this costing system shows a firm resistance to the multiplication of form blanks, and some comparatively unimportant items are not rigorously collected, it is nevertheless true that close approximations to accurate costs are made by its use, and it is also true that these fairly correct costs are obtained by a very small outlay of clerical labor, and the long-continued prosperity of the company amply proves the practical sufficiency of this simple set of cost-keeping forms.

The fact that the boiler-shop gangs are made up of constantly changing permutations of the same workmen, gives rise to the manuscript time sheets in the form of original productions by the hand of the cost clerk for each day's record.

THE ECONOMICAL SIGNIFICANCE OF A HIGH WAGE RATE.

By Percy Longmuir.

In an article in our preceding issue, Mr. Longmuir demonstrated, by an analysis of wages and work in the Midlands and North of England, the fallacy of the idea that low wages for unskilled work were of necessity economical. A fair or even high living wage kept the workman so much more efficient that he far more than repaid his employer's extra outlay. In the following paper Mr. Longmuir applies a similar argument to the case of the skilled worker. Both phases of the discussion are strongly pertinent to the issue in the United States anthracite field.—THE EDITORS.

IN a preceding article the economy of a high rate was considered in the case of unskilled labour only. With this class of labour the economy is evidenced in the maintenance of a higher standard of physical efficiency, and to obtain this increased efficiency it pays to raise the rate to a sum upon which the worker can with some show of reason store in the requisite energy in the form of food. But even high rates in the case of unskilled labour are of necessity too low to be regarded in any other light than that of maintaining bodily efficiency only. However, as bodily efficiency and mental capacity are associated, the creation of a class of general labourers so equipped forms a good reserve upon which to draw for handy men and semi-skilled workers. An avenue is thus opened by which the general labourer commences to ascend the industrial ladder and to attain rates which offer more advantages in the way of living. A method of selection is opened to the employer, which, judiciously handled, acts as a powerful stimulant in developing a spirit of enterprise in bodies of men who otherwise are in a state of apathy.

With skilled workers the rate is, generally speaking, decidedly above Rowntree's poverty line* and in considering the economical significance of high or low rates other factors than the one adopted in the case of unskilled workers must be considered.

In the first place, the word economy is one which permits of wide application; but narrowing down the general sense of the word it may be taken as the careful and judicious use of anything, such as time, material, labour, money, etc. Thus thrift and economy are in some respects synonymous terms, thrift being generally taken as econom-

* The minimum upon which it is possible to maintain mere physical efficiency. For a family of five, under average conditions found in Great Britain, Rowntree's "poverty line" is an income of 21s. 8d. ($5.20) a week.

ical management. In any form of works management thrift is essential to success, but the measure of that success is dependent on the particular form of thrift adopted. For instance, there are many familiar examples of thrifty men who, in spite of their very evident economy, make little or no headway and who possess none of that healthy vitality so necessary to real advance. It follows that in undue straining after economy the vision is warped and the outlook narrowed —hence the loss of vitality. Economy to be genuine must be rational and broad; it must look not at the immediate present but make provision for any possible contingency likely to arise. The latest development of this spirit of far-sighted economy is to be found in the use made of the scrap heap by progressive establishments. To this heap are relegated methods and tools the moment they can be replaced by better ones, and it is recognised that it is with the best, and only the best, tools or methods that full success will be achieved. It is apparent that methods of management have as important an effect on the character of the work produced as have the tools and appliances.

Sympathetic methods of management have been scoffed at as bribes to the worker to be a sort of "good child." High rates are in many cases regarded in the same light, epecially by those who pay low ones. It is surely unnecessary to state that such views are short-sighted, for sympathetic methods are based on a very full grasp of human nature which recognises that better treatment on the part of the management yields correspondingly better results from the worker. Therefore high rates are an incentive to greater effort on the worker's part, and up to a certain point this effort will increase with the rate, in that an ascending rate produces a higher calibre of workers. Successful economical management lays stress on the necessity of obtaining the greatest possible output per unit of production. This highest possible must be obtained alike from each individual man and each separate machine, and when obtained can be taken as representing the judicious and far-sighted economy defined in the preceding paragraph. As far as the machines are concerned, before such a state of efficiency is obtained much outlay of thought and capital will be required. This is generally recognised, and tools are the subject of thought and experiment before purchase. But how much thought or experiment is devoted to the question of human tools? In the majority of cases practically none. Full economy is a matter of the best tools, the best workers, and the best methods, none of which can be secured without an outlay of thought and capital; and in practice it is found that the greater the expenditure of these joint factors the greater is the return.

As the economy obtained from good tools is necessarily co-existent with and dependent upon that obtained from good workers, it follows that the latter must receive as much thought as the former. An equivalent outlay of the joint factors in both cases is essential to full economy. A tool bought without thought at a high figure will not necessarily prove economical; neither will an indiscriminate increase of wages result in a greater output from the workers. However, the tendency to err in this respect is not great, and where high rates are adopted they are in all cases understood as the reward of efficiency. As with the unskilled workers, so with the skilled one—high rates result in a better personnel, and it is found that the better quality men gravitate to those districts in which wages are highest.

For convenience, skilled-labour rates may be taken as ranging from 30 to 46 shillings per week of 54 hours; these limits also determine for the purpose of this paper the "low" and "high" rates. Some of the contrasts between low and high rates may be tabulated as follows:

Low rated areas in which the rate varies from 30 s. to 35 s.	Low state of efficiency.	1. Low output. 2. High percentage of spoiled work. 3. Poor use of time, material, and tools. 4. Short-sighted narrow outlook—consequently hard to manage. 5. Self esteem and ambition low.
High rated areas in which the rates vary from 36 s. to 46 s.	Greater efficiency.	1. High output. 2. Low percentage of spoiled work. 3. Time, material, and tools used to better advantage. 4. Better balance of mind and wider outlook — consequently easier to manage. 5. Self esteem, intelligence, and ambition higher.

The reduction in percentage of spoiled work with the higher rates is no small item in favour of their economy; this is also associated with a fuller use of time and tools, the latter being made to yield more and at the same time receive better treatment. The economy of material is due in the first place to the lessening of wasters, and in the second to intelligent use. This intelligence is also responsible for the increased output; a thinking worker will make every movement and every stroke tell and will give just the necessary number, neither more nor less. An unthinking one may put in far more strokes than are necessary, every one of which may also vary in effectiveness. The manner in which different grades of carpenters drive home a nail is very instructive in this respect, and also illustrates the fact that though a certain number of blows are necessary, one too many will damage if not spoil

the work. Hence the higher quality found with the increased output of the higher rate is due to the fact that the worker aided by his thoughts gives just the requisite number of effective strokes and no more. The quality of the product is high because the worker's thoughts have been concentrated on his task. The question then naturally arises, why can not this concentration of thought be obtained in the low-rated areas when strict methods of management are adopted? It is true that increasing the strictness does give rise to more thought on the part of the worker, which is devoted not to the work in hand but to devices for hoodwinking the management, and usually the worker is successful. Continued hustling can succeed in producing a mere show of work only; real concentration on the worker's part will never be obtained in such a manner. Judicious management recognises that it is true economy to purchase a tool costing £75 which will produce twice the amount of work yielded by one costing £50. So with the human element; if one man at 40 shillings will produce twice the amount of work to be obtained from one at 30 shillings, then on the face of it the former is the more economical man. Just as no amount of pressure would make the £50 tool equal the £75 one, so no amount of hustling will make the 30-shilling man equal the 40-shilling one.

High rates are necessarily based on the principle of payment by result, which is translatable into the reward of efficiency. It has been already stated that full economy can result only from the highest efficiency; inefficiency even on the lowest rung of the skilled-labour ladder must eventually prove costly. In aiming for this efficiency the rate of payment should be considered only in the relationship it bears to the ultimate cost of the product. Too often this relationship is ignored and the rate regarded as an entity itself.

High rates have a very marked effect on the workers themselves. In the first place, the increased payment has an educational effect in that it broadens the outlook by widening the worker's horizon. Thus a certain amount of travel becomes possible and holidays can be spent away from home—an educational factor of no small import, for nothing better can be found to rub off the corners than contact with unaccustomed conditions. The increased income gives an assurance which increases self-respect and fires the ambitions, giving a desire to know more and achieve more; thus an interest is aroused in some form of technical or general literature. Increased home comforts are possible—and the taste they awaken, once acquired, the owner usually strives to gratify further. Congenial surroundings give a balance of mind which will effectually minimise industrial troubles.

Quite apart from a lessened cost of production, high rates are economical in that they tend to produce alert and shrewd workers, men who can "see" as well as "do." The better influences at work on the character, due to the possibilities opened out by the higher rate, tend to develope inventive faculties and the power of concentration—two items of great import to the employer.

It will be argued, and with some show of truth, that an increase in pay will benefit not the worker and his family but the publican and the bookmaker. Much colour is lent to this view by the fact that in very many cases nearly the whole of the income is deposited over the bar counter. But a deeper examination will show that in such a case, the workers so doing could not continue long on high rates, the maintenance of which depends on a low cost of production. High rates place a premium on efficiency; the toper and the ne'er-do-weel would therefore, by the inexorable law of gravity, find their proper level, and the worker anxious to master his position would be rewarded according to the execution put forth. Whilst a premium placed on efficiency is necessarily a process in the law of the survival of the fittest, it is humanitarianism in that it gives all a chance to become fit. As in practice there must be degrees of "fitness," so the high rates which are based on merit will reward each degree according to its kind.

Highly paid and highly productive—what vistas do not open out at these thoughts! Workers of such calibre would recognise in greater measure an employer's liabilities; recognising the keenness of competition, they would nerve themselves for the strenuous fight and in so doing bring into play every faculty of mind and body. Economical management will meet competition by the formation of such a body of workers; the fallacy of rate cutting will not be adopted, but cost will be lowered by increasing the quantity and quality of the product. The sympathetic hand extended by the management, when grasped by the worker's, forms a bond for mutual advantage and advance. Industrial difficulties lend themselves to ready solution when each side can to some extent look from the other's standpoint.

Possibly the chief difficulty in the adoption of high rates lies in the present far-reaching system of uniform rates. The latter have a tendency to level downwards rather than upwards; hence uniform rates tend to develope uniform mediocrity. Assuming trade-union restrictions to be absent and high rates based on high productive capacity to be adopted, then this level of mediocrity slowly but most surely changes into one of efficiency. A further question arises in that, supposing high rates to be universally adopted (a rather untenable supposition)

will they not lead to uniformity and its resultant mediocrity? No, the high rate used as an incentive to greater effort can not result in uniformity, for it will always tend to draw out all that is best in the recipients. No worker can have greater incentive to greater effort than the certain knowledge that his strenuousness will be rewarded in kind. It is true that from a certain section of workers the introduction of the high rate would meet with opposition, or rather they would strongly object to the necessary correlative of high production. The home surroundings which develope this attitude of objection have to some extent been examined in an earlier issue of this Magazine.* A further cause may lie in the systematic rate cutting practiced by an occasional firm working on a piece-work basis. In cases of this kind rates are cut because an efficient worker exceeds a certain maximum—a practice which, when recognised by the workers, results in the restriction of their output and brings out a spirit of distrust against any and all new methods proposed by the management. To overcome this spirit of distrust and suspicion the management must be firm in the insistence of the underlying principle of the high rate—that of a low cost of production. If the worker knows certainly that increased production means increased pay, and that no matter how high a sum he may earn, provided his production corresponds to his pay, the rate will not be cut—then in very truth he has strong inducement to work to full capacity. The educative effect of the higher rates already referred to will go far to remove these and other difficulties of the industrial world.

The economy of a high rate is generally recognised in positions of trust; for instance, the general manager of a large concern is not selected because he may be the cheapest man but rather for his efficiency. Indeed, all experience goes to prove that in the end the best obtainable is in every case the most economical.

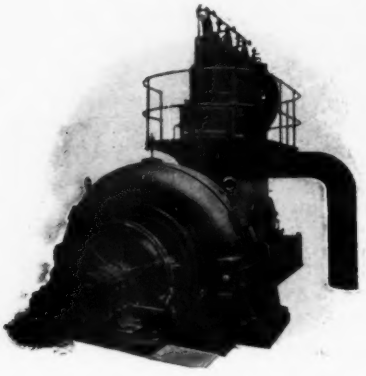
Therefore if it be wiser to have a skilled doctor and an expert lawyer, if it be of more pleasure to listen to a prima donna than an artiste of fourth or fifth rate, it it be of more profit to have the services of a good tailor and a first class cook, will it not also prove economical to have the service of efficient workmen—even though their rate may be high?

* The Home Environment of British Workingmen. Percy Longmuir. THE ENGINEERING MAGAZINE, January and March, 1902.

ELECTRICITY IN MODERN STEEL MAKING.

By John Hays Smith.

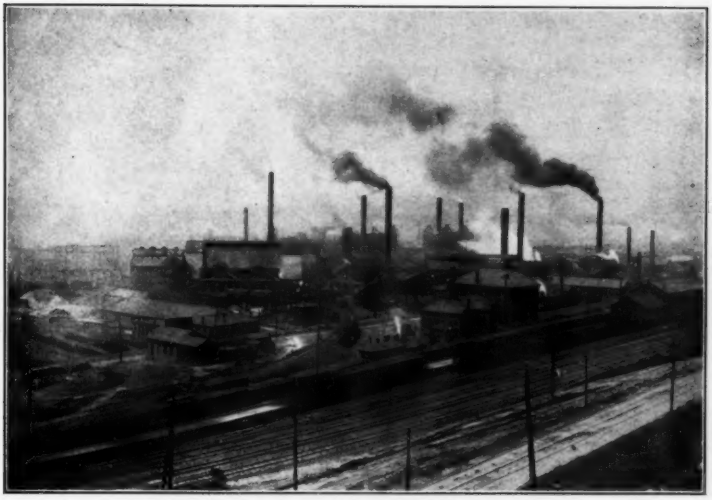
In the literature of engineering, a peculiar value is attached to the actual description of what has been done, tested, and proved good. This quality of definiteness and concreteness is markedly present in Mr. Smith's account of the utilization of electricity in one of the most famous steel works in the world.—THE EDITORS.



FROM the window of the swiftly flying Pullman, when some miles east of Pittsburg, the traveler gets a hasty view of a long line of blast furnaces half veiled in murky smoke and steam, a glimpse of swiftly moving red-hot bodies that pass within the buildings in the foreground, and a momentary view of a lashing yellow flame suggestive of Vesuvius or Mount Pelée. This is the famous Edgar Thomson Steel Works, the largest rail-making establishment in the world, and an integral part of the Carnegie Steel Company, which has recently been merged into the United States Steel Corporation. It was here that Andrew Carnegie first made a success of the steel business.

The Edgar Thomson plant is designed and arranged solely for the manufacture of Bessemer steel rails. The process is continuous from the time the ore is dropped into the furnace top until it is transmuted into its final form—a finished rail. The material, through all the intermediate processes, is never permitted to grow cold. The white-hot iron drawn from the furnace is carried in great vessels to the Bessemer house where it is transformed into steel. The molten steel is cast into ingots and then rolled into rails. All this takes place by a series of closely related processes, marvelous in the facility with which they are completed and wonderful for the fewness of men required to carry them out.

When all nine blast furnaces are in operation they produce sufficient metal to make 2,200 tons of finished rails each day, or enough to



GENERAL VIEW OF THE EDGAR THOMSON STEEL WORKS.

lay 12½ miles of single track with the heaviest rails that are made—one hundred pounds to the yard. Figures give but an inadequate idea of the production of the works. A year's output is more than sufficient to lay a single track railway across the United States from ocean to ocean. In the twenty years of operation there have been produced more than 200,000 miles of rails, sufficient for thirty tracks side by side from New York to San Francisco.

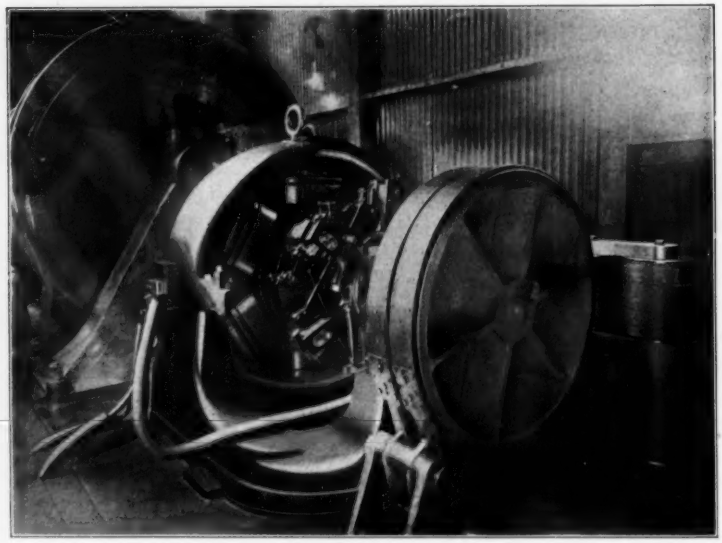
One of the most potent factors in the development of these works has been the use of electrical apparatus. A modern central station distributes electricity to the various machines, formerly driven by small steam engines. Steam was then supplied by long leaky pipe lines, and the loss of heat by radiation was very large and the condensation of water in the pipes troublesome. Now, a few slender wires replace the large and cumbersome steam pipes, and at the end of the transmission line an electric motor supplants the steam engine.

The introduction of electricity in rail making and the substitution of the electric motor for the steam engine have largely come about through the far-sightedness of George Westinghouse and the enterprise of Charles M. Schwab. In the operation of natural causes constantly at work revolutionizing American industries, capital has been plenty and labor always costly as compared with European labor and capital engaged in the same industry. In America neither brains nor

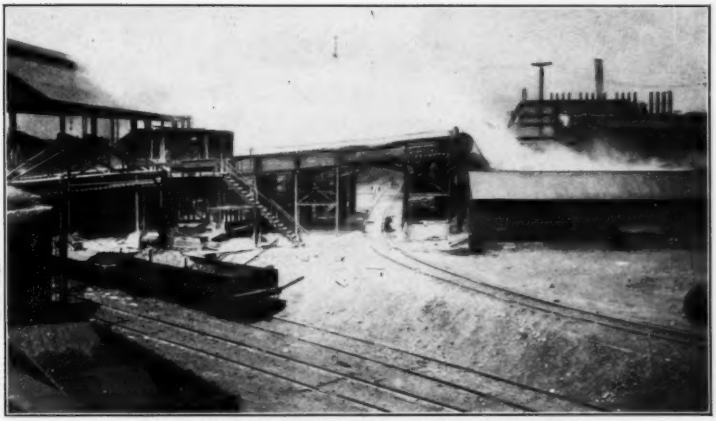
money has been spared in the endeavor to cut down the labor item, either by the entire substitution of mechanical processes, or by the improvement of rough devices already employed. Even the best known method of doing a thing has never been sufficient to the American manufacturer. He must always have a better method—one that makes a better article, saleable at an increased price, or the same thing at a reduced cost; in either case a larger profit.

The Edgar Thomson works, without adding to its equipment for rail-handling, has greatly increased its output during the past five years. This enlarged production has been made possible by using electricity to operate the various metal saws, roll tables, cranes, rail conveyors, and machine tools. In adopting electrical inventions (the machinery is almost all of Westinghouse make), two paramount considerations have governed—reliability in service, and the increase of output with greatly decreased labor costs. It was desired to make the operations as nearly automatic as possible. Reliability was therefore of the first importance in this manufacturing establishment where the cessation of a single operation in a series of related processes means the shut down, or at least the crippling, of an entire plant.

To obtain a clear understanding of the part that electricity plays in



ELECTRIC MOTOR HOIST, ELEVATING ORE, COKE, AND LIMESTONE TO THE TOP OF THE BLAST FURNACE.

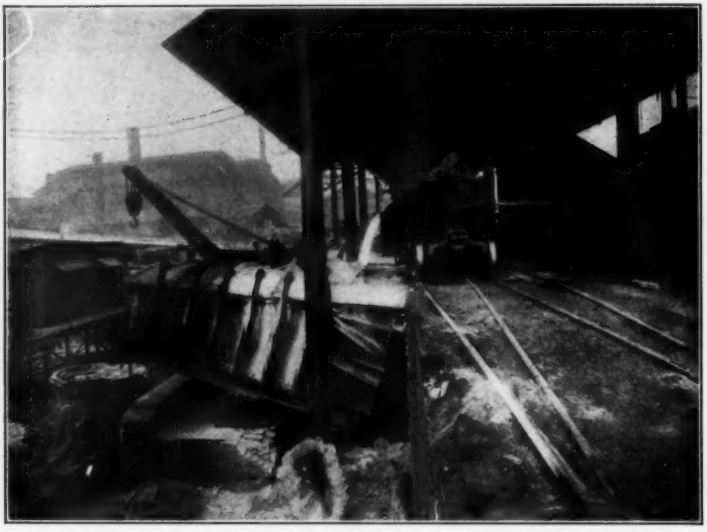


PIG-CASTING MACHINE DRIVEN BY ELECTRIC MOTORS.

the process of rail making, the onward movement of the raw material, the metal, and finally the rail, must be followed. The point of departure is the ore yard. Beyond the great mass of iron ore that steamers and railroads have transported from the Mesaba range, and which has been piled at this spot, stand the furnaces flanked by their stoves. Up the sides of the blast furnaces, by an almost vertical incline, pass swiftly moving cars carrying the ore, coke, and limestone in the exact proportions requisite for the production of iron. Electric motors hoist and dump the contents of these cars into the furnace top. Two thousand tons of material are poured into each furnace daily, and yet a single man at the hoist represents the only human agency connected with the lifting, tipping, and returning of the cars.

Formerly the molten metal from the furnace was run into sand moulds, requiring for the casting a large space over which a rather pretentious shed was erected. The present operation of casting is striking and if the time of casting be night, the cast-house is the scene of a most magnificent spectacle. A few workmen tap the furnaces to waiting cars on the track outside. Each furnace is tapped every three hours, but the times are so arranged at the nine furnaces that every twenty minutes a train load of metal is hurried off to one of the two "mixers" shown in the accompanying illustration. These are large boxes of peculiar construction and exceptional strength, into which the metal from the various furnaces is poured from the metal cars, for the purpose of making a mixture uniform in quality. The pouring is accomplished by an electric motor

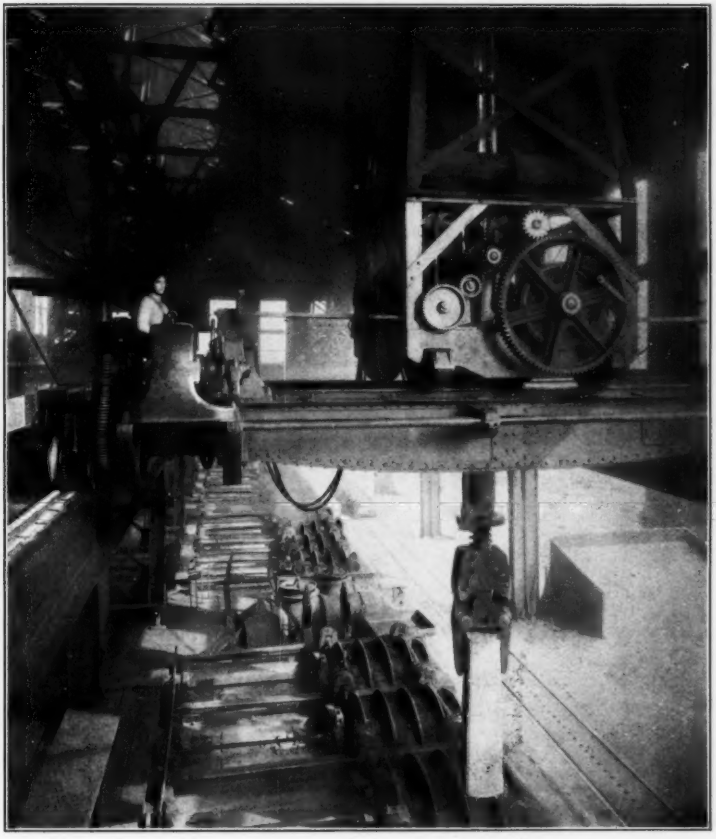
placed within the house to the right and tilting the car by means of the turning bar reaching out from the house to the metal car. The enormous tanks of liquid metal are also tilted by an electric motor and their contents poured into other metal cars standing below. With an envelope of heat overwhelming and stifling, this second train of rocking, metal-splashing cars makes its way to the converter house where the metal is refined into Bessemer steel.



ELECTRICALLY OPERATED CAR POURING HOT METAL INTO THE MIXER.

The converter house contains four Bessemer converters. Behind them, fifteen feet from the floor, are the tracks upon which the metal cars arrive from the mixer. It is the work of a moment to couple the electric motor to the turning bar that tilts the car over, discharging its white-hot and liquid metal into the mouth of the converter which has been turned down to receive it. Then back swings the converter with a quickness wonderful for such a ponderous vessel.

When the blow is completed, a great ladle receives the metal and carries it to one side, filling the ingot moulds that stand on small but massive iron cars. As soon as the metal has solidified sufficiently to permit of the removal of the mould, this is lifted off by a machine called the "stripper." The metal mass, now solid on the outside and fast cooling within, is not yet ready for the rolling process. The preparation for the rolling process is almost as important as the process itself.

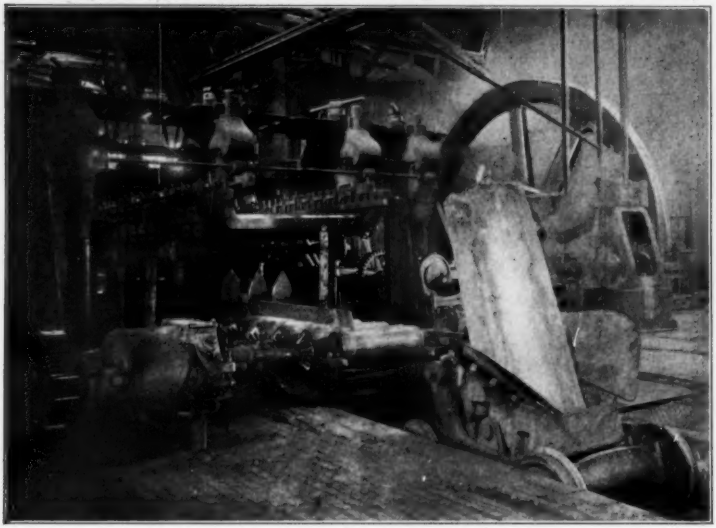


ELECTRIC TONGS HANDLING INGOTS OVER THE SOAKING PITS.

It has been found by experience that the life of a rail depends very much upon its physical history and, consequently, the rolling process has been very carefully studied in connection with the wear of the rails. The best wearing rails are those which have been rolled from ingots of the same temperature throughout. Therefore, before rolling, the unevenly cooled ingot is brought to a uniform temperature and one best adapted for making a rail of good wearing quality. This is accomplished in reheating furnaces called "soaking pits," partly because of their underground construction and partly because of the heat-soaking process to which the ingots are subjected. The illustra-

tion shows them as subterranean furnaces with horizontally opening doors at the top. Along one side is a narrow track over which the metal cars travel to the soaking pits. Above the bank of furnaces are four monster electric tongs always busy in lowering or raising ingots. Beyond the line of furnaces is another line served likewise by electric tongs. The tongs are suspended from a derrick-like car that travels back and forth on the bridge of an electric crane, which runs above the entire line of furnaces. When all four cranes are moving back and forth, now raising and now lowering the white-hot ingots, the eye is fairly dazzled by the complex, swiftly moving cranes, and the flashing ingots with their overpowering heat.

Not only is the ingot hoisted electrically from the soaking pits, but also electrically conveyed to the blooming mill about 100 feet away.



BLOOMING MILL, SHOWING INGOT ON ELECTRICALLY OPERATED BUGGY, READY FOR ROLLING.
Motor-driven roll-table and driving motor to the left.

The crane man, who operates the monster tongs, places the ingot on an electrically driven buggy. Another attendant quickly sends it off on the latter, bringing it up at the blooming rolls, as seen just above. By a lever the buggy is tilted and the ingot falls on the short train of small rollers ready to be rolled into a bloom. At the will of the same attendant, another motor drives the roll train, carrying the ingots upon the roll table and into the blooming rolls. A powerful engine drives the

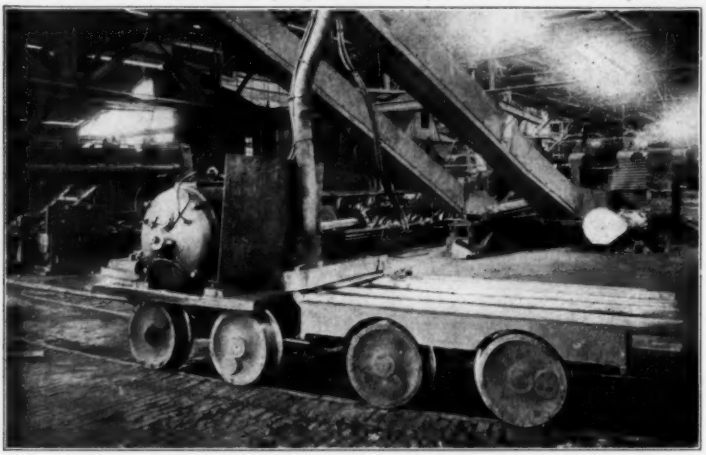
middle roll, which, artificially roughened, catches the metal and squeezes it through. After a number of passes the metal becomes a bloom about 15 feet long and 9 inches square. It has, in the process of rolling, acquired a fibrous structure and is therefore tougher than before rolling.

ELECTRIC MACHINERY HANDLING SCRAP FROM THE BLOOM SHEARS.

The next process is to cut the long bloom up into small blooms, each of which is afterward rolled out 90 feet to a three-rail length. From the blooming mill, by electrically driven rollers, the bloom passes to electrically driven bloom shears which cut the red-hot steel into sections, of length suitable for rail rolling. The rough ends of the bloom—"crop heads"—are cut off and drop down a chute into a car which from time to time is electrically hoisted up an incline. This "scrap metal" is then placed by an electric crane in a railroad car for shipment to any part of the extensive Carnegie mills. Formerly eight to ten men were employed in wheeling the crop ends out from the bottom of the chute; now a boy with a helper disposes of them. The saving in labor effected at this point of the manufacture is not considerable

in itself, but the arrangement illustrates in a pointed manner the methods used in bringing about a cheapened production of steel rails.

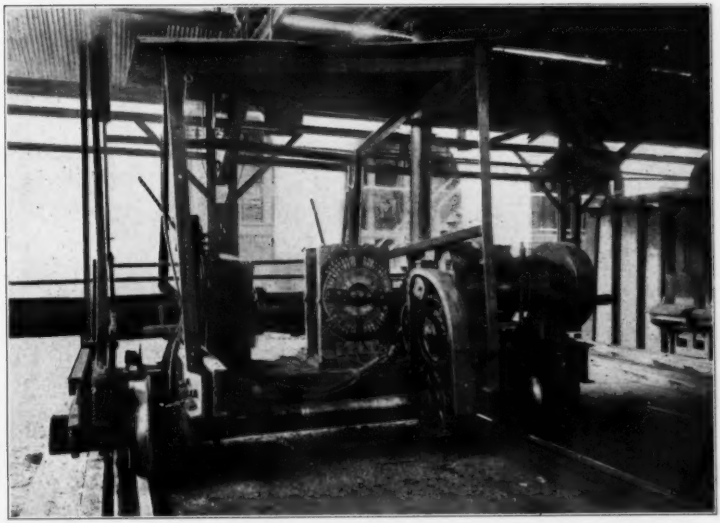
Before the sheared bloom is finally rolled into rails, it is again placed in a reheating furnace. The electrical arrangement used in conveying the bloom from the shears to the furnace is unique and to the casual observer somewhat mysterious in operation. From the shears to the extreme reheating furnace extends a tortuously curved track, perhaps 150 feet in length, over which passes a swiftly moving electric buggy, driven by the motor on the front. The blooms are carried on the car, shown empty in the illustration on this page. Formerly a small locomotive was used in drawing the bloom carriage, but the use of a motor for this purpose has dispensed with the dirty smok-



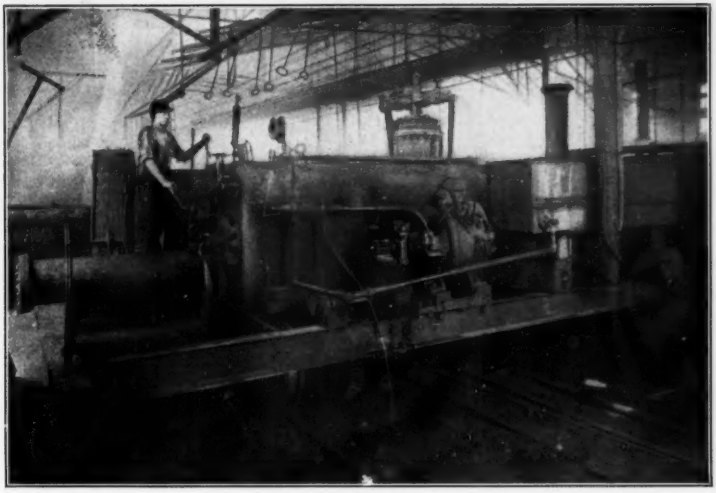
THE MOTOR-DRIVEN BLOOM CARRIAGE.

ing locomotive, and has contributed much toward making this part of the mill clean. When the bloom is brought in front of the proper furnace it is thrust in by a bloom-charging machine standing on a wide track, just outside the bloom-carriage track. The machine shown on the opposite page is electrically driven and carries a long hydraulic plunger for pushing the metal into the furnace.

Above the charging machine is a trolley line, constantly supplied with current; and above the bloom-carriage track is another trolley line which can be electrified at the will of the operator on the charging machine. It is by this means that the bloom carriage is moved. A lever controls the movement of the charging machine in front of the furnace, another lever throws out the plunger thrusting in the bloom.



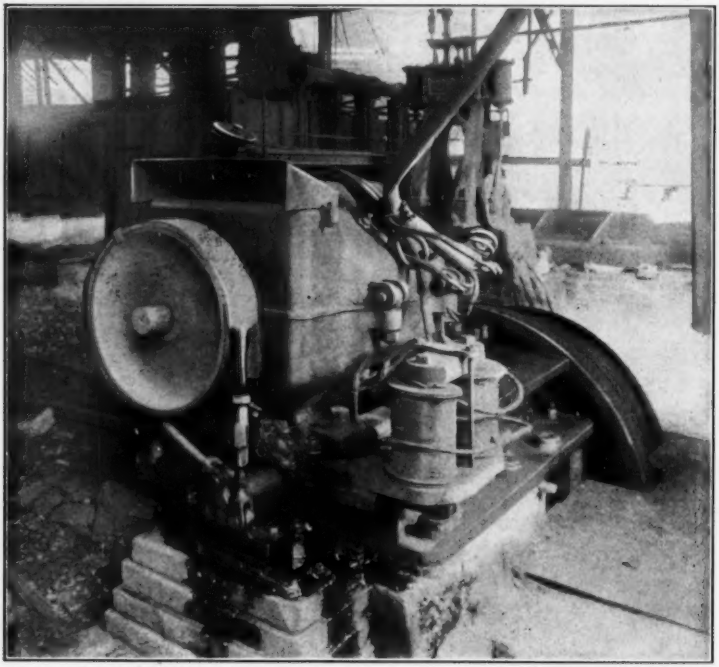
ELECTRICALLY DRIVEN BLOOM-CARRIAGE MACHINE.



OLD TYPE OF STEAM-ENGINE DRIVEN BLOOM-WITHDRAWING MACHINE.

The boiler and engine shown are no longer used. The motor in the foreground now runs the machine back and forth in front of the furnaces. The photograph is interesting as showing a stage of transition toward the apparatus illustrated just above.

The same operator standing on the electric charger raises the furnace door, while by still another lever he controls the movement of the bloom carriage. Thus a single operator carries for considerable distance a load of blooms weighing in the aggregate a couple of tons, and, unaided, puts them into the furnace. Here again electrical arrange-



MOTOR WHICH HANDLES REHEATED BLOOMS, HAULING THEM VERY RAPIDLY TO THE RAIL MILL.

ments, labor-saving and most ingenious, testify to the ingenuity of the men who made these mills world-famous.

The workmen term the bloom carriage a "go devil," although the term is usually applied to the manipulator of the blooming mill. There is something uncanny in its swift, tortuous, and apparently uncontrolled movement, operated as it is by a man who seems to be giving his attention to one machine—the charging buggy—while in reality he divides it between the charging machine and the "go devil."

When a bloom has been reheated, it is drawn from the furnace on the opposite side by an electric "drawer" similar in every respect to the charging machine, and deposited on a buggy driven as shown

above. It is then carried to the rail mill, where the transfer to the rolls is effected by a line of electrically driven rollers. Here begins the final process—the making of the rail. The shaping is by iron hands. The workmen are few in number and in the strict sense of the word not workmen; they only direct the movements of complex and ponderous machinery.

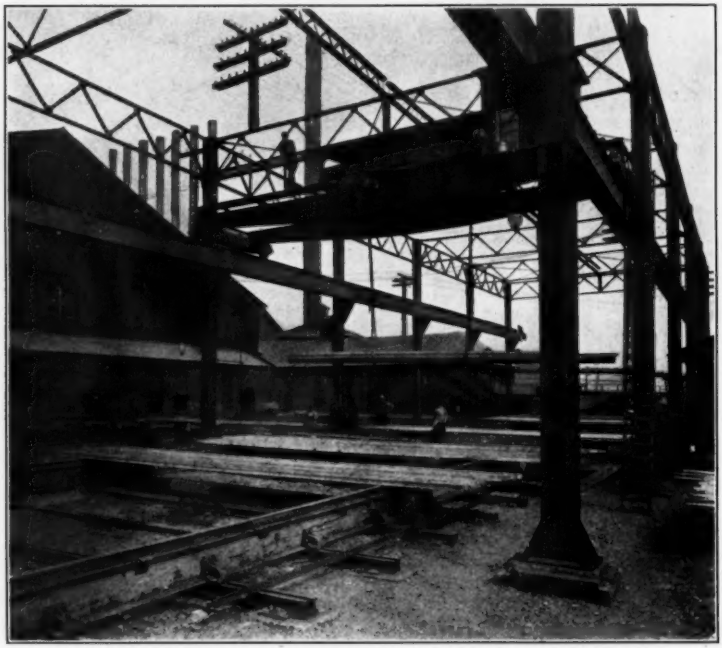
Everything except the heavy rolls that shape the steel is electrically operated by the mere movement of levers. The requisites for the work are a sure eye, a prompt hand, and a clear head. In the pulpit that gives a commanding view of the rolling and conveying machinery, and at the various machines, are a few operators. The red-hot steel passes into the rolls and, rushed back and forth on electrically driven rollers, it lengthens with each pass until finally it runs out a thick bar about 30 feet long, when a set of transfer arms picks it up and throws

MOTOR-DRIVEN ROLL TABLES IN THE RAIL MILL.

Showing two of the motors and the manner in which they drive the rollers.

it bodily to a second set of rolls in line with the first set—much as a row of men standing in line would toss a plank back over their heads. In this set of rolls the steel bar, under the gentle press of the roll, quickly reaches a length of 100 feet. Just beyond, a third set of rolls receives the rail and finishes it off into its final and familiar T form.

From the finishing rolls, on electric rollers, the long rail passes to the hot saws. A touch of the lever, and rapidly rotating saws, electrically driven, cut the rail in three pieces each 30 feet long. From the saws, the rails pass one at a time to the "curver," a machine that puts a camber into the rail, so that in cooling the rail will settle into approximate straightness. The "curver" puts just as much arch into the rail as gravity can remove during the cooling period. Thus a simple machine obviates much labor that later would be necessarily difficult



ELECTRIC CRANE LOADING FINISHED RAILS ONTO CARS FOR SHIPMENT.
Electrically driven rollers, leading from the building on the left, bring the rails out from the last finishing process.

with a cold rail. From this point the rails pass out on the "hot bed," a skid constructed of rails and provided with electrically moving clutches. In groups of four or five, the rails go to the electric straightening presses, and then finally to electric drill presses that pierce the holes through which the rails are afterwards bonded together. Lastly, a motor-driven rail conveyor carries the finished rails out to the shipping skids. They are ready for the markets of the world.

ELECTRIC LOCOMOTIVE USED IN HAULING RAILS.

From the beginning to the end of the process, man has not touched the metal. His has merely been the hand guiding gigantic machines. The various furnaces, rolls, conveying devices, and machinery handling the rail, each contribute toward its perfection and final form, and are to be regarded as the parts of a nicely adjusted machine, the harmonious working of which is essential to the completion of the finished product. The various stages of manufacture are closely timed as the movement of a clock. From the time that the ore is lifted from the ore bins until in the form of finished rails it is loaded in the cars for shipment, the process of manufacturing is moving on a time schedule. Electricity is everywhere the vitalizing energy.

THE FOUNDATION OF THE JOHN FRITZ MEDAL.

An Editorial Comment.

IN the establishment of the John Fritz gold medal the engineering profession in the United States has performed an action of twofold importance; it has honored in a most distinctive manner the name and work of the dean of the profession in America and it has provided an incentive to others to follow in his footsteps.

Founded by the joint action of the four great national engineering societies, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, and the American Institute of Electrical Engineers, and intrusted forever after to a commission composed of representatives of these four societies, the John Fritz medal in its foundation expresses a remarkable agreement of the profession upon one of the greatest factors in engineering progress, and upon the part Mr. Fritz has borne in the perfection of steel making; in its perpetuation, the honor of its award will constitute the goal toward which the energies of ambitious men in all branches of the profession will be bent.

Born in 1822, Mr. Fritz has been engaged during his long life entirely in the development of the iron and steel industry of the United States. Such a career covers practically all of the developments in iron manufacture since Cort invented the puddling furnace, and all of the tremendous expansion in the manufacture and use of steel which followed the epoch-making inventions of Bessemer, Siemens, Martin, Gilchrist and Thomas.

Mr. Fritz's work has been mainly that of a developer of processes which, while they may have had their origin elsewhere, have found

their fullest fruition in the mills, forges, and machine shops of the United States. It was he who with the lamented Holley and with his brother George Fritz, practically initiated America into the possibilities of the Bessemer process, and it is in his footsteps that the men who have since carried on the work have trod. Under his masterful, conservative, comprehensive guidance there have grown up in the United States such works as those at Johnstown and at Bethlehem, with all the development of the modern three-high rolling mill, the hydraulic forging press, the nickel-steel armor plant, gun forgings, structural-steel production, and the whole transformation of modern materials of engineering; and today he stands as the concrete representative of modern engineering in all its highest achievements.

Mr. Fritz has had the rare privilege of receiving in his lifetime the honors which too often come only when they can no longer be a gratification. He has been successively president of the American Institute of Mining Engineers, and of the American Society of Mechanical Engineers. He is an honorary member of the Franklin Institute, and the honored recipient of the Bessemer medal at the hands of the British Iron and Steel Institute.

Perhaps no better summary of the work in which Mr. Fritz has taken such a controlling part can be made than to quote from his own Presidential Address before the American Society of Mechanical Engineers, delivered in 1896.

> "The modern practice of steel making has, in the hands of the mechanical engineer, the metallurgist, and the chemist, wrought wonders in producing a material which in quantity, physical qualities, and cheapness would have been regarded as utterly impossible half a century ago, when steel rails, beams, angles, and plates were not thought of, and steel was regarded as a luxury among the materials of the working artisan. The labor of the men of iron and steel has so cheapened their products that to-day we are enabled to use steel for the commonest purposes as well as for the most expensive articles produced by the skill of the mechanic. No article is too humble to be made of it, and no structure so grand and important as to refuse its services; it is demanded in the frying pan as well as in vast bridges and viaducts, as well in the housewife's needle as in the great leviathans which have made the ocean a span of less than a week; thus we find steel asserting its value through every walk of life, and extending to every clime, linking lands in that bond which grows broader and stronger with the years, till even now we see, if but dimly, on the horizon the promise of the linking of nations in the universal brotherhood of mankind, and bringing the longed-for era of eternal peace."

And then, at the close of his eloquent address, Mr. Fritz might well have added, had his gentle and characteristic modesty not deterred him: *"quorum pars magna fui."*

THE PREVENTION OF ACCIDENTS TO WORKMEN IN FRANCE.

By Jacques Boyer.

The protection of workmen from injury while in the performance of their duty has been made a subject of frequent legislation in France, besides which the important Association des Industriels de France has taken an active part in the work by its publications, its inspectors, and its expert engineering advice. Professor Boyer gives a *résumé* of the historical side of the subject, with some account of its present status in France, and the experience thus gained should be of value to employer and employee alike in other countries.—THE EDITORS.

IN France, before the Revolution, the control of each industry was delegated by royal authority to the various municipalities, and no workman was permitted to ply his trade in any locality without being registered in the local corporation. The Constituent Assembly abolished this restrictive policy, and in 1791 proclaimed the freedom of labour, after which the law of 22 Germinal, in the year XI of the Revolutionary Calendar (11 April, 1803) was passed to determine the respective obligations of workmen and employers. Not long afterward, in 1806, an ordinance of the prefect of police limited the duration of the working day upon building work in Paris. Finally, in 1841, the regulation of industrial conditions was seriously undertaken. According to a law passed in the latter year the age of admission for children was fixed at a minimum of 8 years in all workshops, factories, and metallurgical establishments. According as the age of the children ranged between 8 and 12 years, or 12 and 16 years, the length of the working day was fixed at 8 and 12 hours respectively.

The laws of 1848, 1851, and 1874 made successive modifications in these regulations, until the subject reached its present status by the law of November 2, 1892, modified in certain articles by the enactment of March 30, 1900, and by the decrees provided for its execution. So far as the regulations for the assurance of hygienic conditions for workmen provided in the law of June 12, 1893, are concerned, they will also be considered in their proper place.

According to the enactments at present in force, children may not be employed in workshops, mines, mills, or factories before they have attained the age of 13 years. For children, minor girls, and women, the maximum length of the working day was fixed at 11 hours, but since the beginning of 1902 this has been reduced to 10½ hours, and after a period of two years it is to be reduced still further to 10 hours.

Children under 18 years of age, and women, are required to have one day off in each week. With the exception of mines and of establishments in which furnaces are maintained in continuous operation, the hours allotted to repose are required to be the same for the entire working force, in order that the household life of the families may be maintained.

The inspection service is uniform over the entire country. There are eleven division inspectors, with salaries ranging from 6,000 to 8,000 francs, and ninety-two departmental inspectors, with salaries from 3,000 to 5,000 francs. In addition to these there is a superior commission, composed of nine persons, these being two senators, two deputies, and five members, appointed for a period of four years by the President of the Republic. This commission is charged with the duty of maintaining a vigilant enforcement of the laws and also of passing opinions upon questions which may come up for discussion in the same connection. In case of any violation of the laws of 1892-1900, the employer is subjected to a fine of 5 to 15 francs. A repetition of the offense renders him liable to a further fine of 16 to 100 francs. The maximum fine which can be inflicted is 2,000 francs, under certain provisions of the law of 1893. Finally, if the proprietor of an establishment, after a second warning, fails to comply with the measures of security or health imposed by the inspector, the commission is empowered by law to close the works.

General Requirements for Safety in Workshops.—Experience has suggested to French legislators certain regulations as advisable in connection with the construction of industrial establishments, and these will be briefly passed in review. The most important of these relate to the dangers from fire, the conditions concerning which vary according to the nature of the industry. Many new factory buildings are constructed in reinforced concrete, which appears especially well adapted to prevent the propagation of fire. These combinations of iron and masonry are good, provided sufficient play is provided for the expansion of the metallic portions under the action of heat; otherwise there may be danger of rupture and collapse. In all cases the buildings are required to be provided with standpipes, fitted with valves and lengths of hose, for the delivery of water under pressure, the hose being placed in closets provided with glass doors.

Various systems of extinguishers are used in French workshops, the principal form being the Labbé grenade. Nearly all these devices are based on the same principle, that of discharging into the midst of the fire a mixture of water and carbonic acid, or of a saline solution

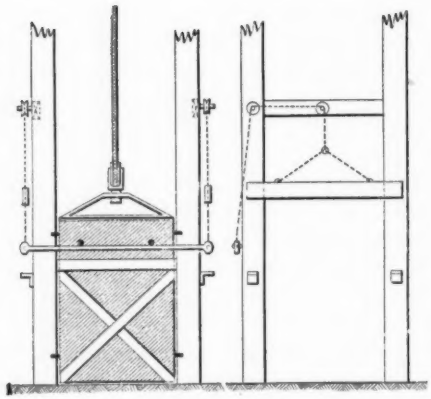


FIG. I. AUTOMATIC SAFETY GATES FOR FACTORY HOIST.

possessing similar properties. The contact of the liquid with the burning material generates an atmosphere which will not support combustion and at the same time isolates it from contact with the oxygen of the air.

Exits from workshops should always be provided with doors opening outward, and the passageways should never be permitted to be encumbered with merchandise, it being required to maintain always an opportunity for rapid exit of the employees in case of alarm. Stairways should be ample in number, and made both large and strong. If the factory consists of several floors, security demands that there shall be at least one stairway of non-combustible construction, and this rule has been formally imposed by a decision of the Minister of Commerce, upon the advice of the committee of arts and manufactures.

Passageways between machines, tools, or other pieces of mechanism should never be less than 80 centimetres (31½ inches) in width. In chemical works especial attention should be provided to prevent accidents from workmen falling into vats, tanks, evaporating pans, or other vessels containing corrosive liquids, this requiring that they be enclosed with railings not less than 90 centimetres high (35½ inches), the rims of the vessels also being made high whenever practicable.

Elevators and hoists of every kind are frequent sources of accidents. In order to prevent accidents by reason of workmen falling down the shafts, the doors should always be kept closed on every floor, except when the cage is opposite, and this is best accomplished by some form of automatic device. This is readily accomplished for the top floor by providing a trap door which is opened by the cage itself, and closes down upon it in descending, while for the ground floor sliding gates operated by chains, as shown in Figure 1, may be conveniently used. For the intermediate floors various devices may be used according to local conditions. In Figure 2 is shown an ar-

rangement frequently employed. On each side of the cage is fixed a bent bar A. A lever B is hinged to the bar A at b, and is also connected to it by a helical spring R, extending from a to c. The doors on each floor are arranged to slide vertically, and are provided with projections E, of sufficient length to engage with the end of the lever B. The doors are counterbalanced to such an extent as to leave a slight preponderance to close them. When the cage rises the levers B engage with the projections E, and the door is lifted, the strength of the spring being somewhat greater than the unbalanced weight of the door. When the cage descends the door is lowered. If the cage continues to ascend the movement of the door is checked by stops and the extension of the spring R permits the lever B to pass the projection E, and the door descends. In descending, the lever B is lifted as it passes each door by contact with the projection E.

Motive Power and Transmission.—In manufacturing establishments in France a special room, usually of ample size, is generally reserved for the prime movers, either steam or gas engines, sufficient space being given for the engineer to obtain complete access to every part of the machine barred to the general public. Hydraulic motors are also usually placed in a separate compartment whenever possible, railings being placed on either side of the entrance and discharge flumes, as well as on both sides of the passageway leading to the regulating gates. Turbines are naturally always enclosed.

Cranks and connecting rods are often the causes of serious accidents if they are not enclosed in railed spaces, and it is customary to provide such guards that accidents can occur only through foolhardiness. When the two portions of a transmission shaft are intended to be coupled or uncoupled at will, some form of clutch gearing must be employed. Various forms of safety clutches have been devised for this purpose, among which may be mentioned the friction pulley of Piat, the clutches of Edmeston and Snyers, and the automatic clutch of Brancher. A typical devise is the clutch of M. L. Barral, in which the friction blocks are operated by the differential angular movement of the

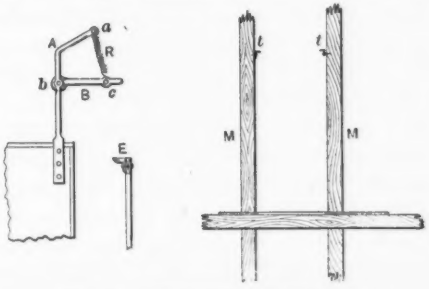


FIG. 2. AUTOMATIC OPERATION OF ELEVATOR GATES.

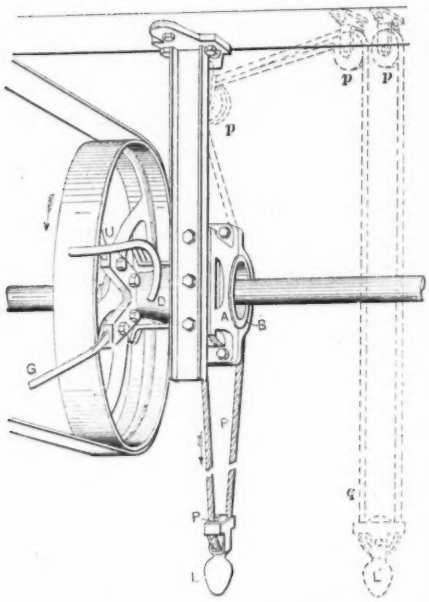


FIG. 3. PIAT BELT SHIFTER.

two shafts until the coupling is effected.

Pulleys which are placed but a small distance above the floor must be protected by being boxed in. Vertical belts should be entirely enclosed in casings of wood or sheet iron. Horizontal belts should be protected so that accidents may not occur in case of their rupture, this being the only danger which need be guarded against, the simplest plan being to place beneath them a shield suspended from the ceiling, or supported from the floor or from the walls.

When a horizontal shaft passes beneath a staircase the belts may be protected by an enclosure extending from the ground and enclosing the pulleys.

The handling of belts may become the source of serious accidents and hence numerous devices have been employed to permit them to be managed in safety. I may here indicate the principal methods employed, according to the excellent work *"La Securité du Travail dans l'Industrie,"* by M. Paul Razous, departmental inspector.*

For shifting light belts a simple pole with fork may be used. For heavier belts this cannot be employed with safety, and some form of belt shifter must be mounted by the side of the pulley. A number of such devices have been constructed, among which may be enumerated those of Biedermann, Baudoin, Brancher, Piat, Forest, etc., etc. As an illustration I may describe the usual construction of the firm of Piat. This apparatus, Figure 3, which is intended for belts not ex-

* Paul Razous. *La Securité du Travail dans l'Industrie.* Paris, Ch. Dunod. In the course of this article I have had several occasions to use this remarkable book, written by an official who has had excellent opportunities of obtaining authoritative information concerning the methods employed in France for the prevention of accidents in workshops and factories.

ceeding 8 to 9 centimetres in width (3 to 3½ inches), is composed of a sleeve carried by collars A, B, and operated by an endless cord P. Two wrought-iron arms, U and G, are used, one to unship the belt and the other to replace it on the pulley. The operation is as follows: The belt being off the pulley, a partial revolution of the sleeve may be made by pulling upon one part of the cord, while the other part is held taut in order to maintain sufficient frictional contact. As a result of this movement the arm G leaves the belt, which is picked up by arm U, and delivered to the pulley. The belt is unshipped from the pulley in a similar manner.

The methods employed to prevent the bursting of grind-stones, emery wheels, and fly wheels are now generally designed in view of the provisions of the act of March 10, 1894. In the case of ordinary grind-stones, used for sharpening tools and revolving at a moderate speed, there is little or no danger to be apprehended. For wheels of natural or artificial abrasives, employed for polishing or cutting metals and operated at high rotative speeds, the action of centrifugal force must be considered. Since the stresses increase according to the square of the velocity, according to the mass, and to the radius of gyration, these may become enormous at the high rotative speeds frequently used, and may occasion the rupture of the wheels with consequent risk of fatal or serious injury to the operatives. In order to minimise the risk of such accidents the French administration has recommended that the circumferential velocity shall not exceed 13 metres per second, (42.6 feet per second) for natural grind-stones, and 25 metres per second (82 feet) for artificial wheels. Grinding wheels are now frequently made double-conical in shape, as shown in Figure 4, with a greater thickness at the centre than at the circumference, and mounted between two plates under which are washers of felt or rubber. Such wheels usually break across one diameter, and the plates and washers aid in holding the fractured pieces together.

FIG. 4. SAFETY MOUNTING FOR A DOUBLE-CONICAL GRINDING WHEEL.

In order to avoid accidents from the bursting of fly wheels, it is necessary to use cast iron of the best quality and to form the rim so as to offer a minimum degree of resistance to the air. In some instances the rims have been built up of wrought iron or steel and in other cases they have been reinforced by a wrapping of steel wire. It is also

most important that the engine should be furnished with a reliable regulator, in order that a uniform speed may be maintained and that the engine may not "run away." The Farcot governor, a modification of the original ball governor of Watt, is much used in France, because it is nearly isochronous and maintains a very uniform speed of the engine in spite of great variations in resistance. For high-speed engines, however, shaft governors are generally preferred, the Lecouteux, Garnier, Westinghouse, and others being used.

Another feature of much importance in connection with safety is that of provision for the prompt stoppage of the engine in case of accident, such as that of a workman being caught in a coupling, shaft, wheel, or other part of the machinery. For this purpose it is not unusual to find the various rooms of a factory connected with the engine room by electric annunciators. This provision, however, is not always sufficient. Much precious time may be saved by providing a direct control of the engine from the possible scene of accident, and several devices have been produced for this purpose. Such an apparatus, operated electrically, has been devised by M. Ressenon, and another is made by Dollfus-Mieg & Cie. By pressing a button in any one of the workrooms of an establishment, the following succession of actions is produced:—1, the closing of the steam stop valve; 2, the shutting off of the condensing water; 3, the application of a powerful brake against the fly wheel.

Another method of providing means for suddenly stopping the machinery is that of using some form of connection between the motor and machinery which may be promptly disconnected. For this purpose various forms of clutches are used, the simplest being the ordinary jaw clutch, consisting of one sleeve with projecting teeth fixed upon the driving shaft, and another with similar teeth sliding on a feather on the driven shaft, a lever enabling the latter to be instantly drawn out of engagement. Friction clutches are also employed.

In establishments in which hydraulic power is used it is more difficult to stop the motion suddenly. The only methods in practical use are those of closing the gates by hand, or by the use of clutches for disconnecting the machinery from the wheels. As by far the greater number of hydraulic power plants are also those in which the power is electrically distributed, however, the shutting off of the current by convenient switches is generally available.

In regard to the question of dangers accompanying lubrication of machinery, the French laws specify that whenever possible machinery shall be lubricated when not in motion. If continuous lubrication is

necessary it should be effected by automatic devices, which can be replenished when the machines are standing. Trains of gearing should be lubricated only through proper openings provided in the cases in which they are enclosed.

The Guarding of Machine Tools.—Having considered the principal methods of preventing accidents in connection with the motive power machinery, it remains to consider the principal tools and machines themselves; referring especially to methods and appliances used in France.

In wood-working establishments especial attention should be given to circulars saws, band saws, and hand jointing machines, or hand planers, as the latter are sometimes called. The accidents occasioned by circular saws are due either to the contact of some portion of the body of the operator with the teeth of the saw, or to the projection of pieces of wood back over the top of the saw. The latter class of injuries is not at all uncommon, the short ends cut off by the saw catching in the teeth and being thrown back with great force against the head of the operator, frequently with fatal results. Accidents from cutting are best prevented by surrounding the saw with some form of guard, while at the same time it is advisable to make it very convenient to stop the saw readily, in order to remove the temptation to clear away sawdust with the hand while the saw is running.

Accidents due to the projection of pieces over the saw may be prevented by arranging a dividing blade by the side of the saw, back of the centre, so as to guide the cut off piece away from contact with the saw teeth. A heavy plank, suspended from the ceiling in front of the workman, may be made of such a length as to permit unobstructed vision of the work, and yet furnish complete protection against flying blocks.

In view of the numerous accidents from cutting by circular saws, the *Association des Industriels de France* instituted a competition for the design of a satisfactory form of safety hood. The conditions required that the protecting device should permit pieces to be sawed readily, either longitudinally or across the length, and that it should operate automatically, both as a guard against cutting the operative and against injury from projected blocks. Numerous inventions have been submitted in consequence, and from the report of M. Mamy, the director of the association, is taken the description of the apparatus of M. Fleuret, which received one of the awards in the competition. The Fleuret safety hood, Figure 5, consists of two arms, G and H, hinged upon the same pivot O, mounted in the slot S, of the support S.

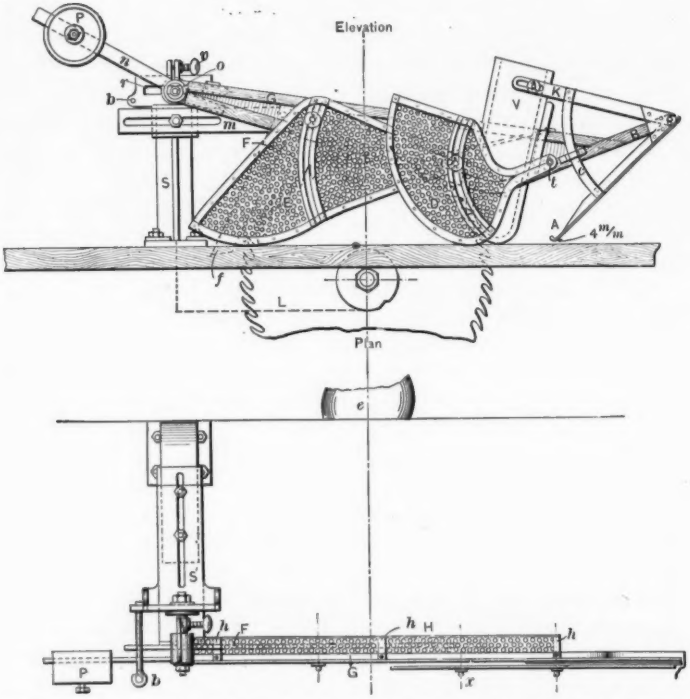


FIG. 5. PLAN AND ELEVATION OF FLEURET SAFETY HOOD FOR CIRCULAR SAWS.

the arms being connected by a piece of perforated sheet iron. The extremity of one of the arms, B, carries a sort of jointed angle K, similar to a pair of compasses, guided by an arc c. The extremity of K carries a slotted piece engaging with a pin on the slide V. The first screen d, made of a frame of iron covered with perforated sheet metal, oscillates about the point t, its movement being guided by the quadrant and pin x, which latter serves as a point of suspension of a second screen E. The dividing knife F, attached to a flat iron bar m, is so adjusted that it enters into the line of cut of the saw. The various parts are provided with adjustments, so that they can be adapted to the saw which may be in use. The action of the apparatus is as follows:—The entering piece of wood raises the foot A, and thus lifts the slide V, this latter then resting on the piece until it is nearly cut through. The screens D and E., are successively lifted by the piece to be cut, so that at no time are the teeth of the saw exposed where they

can be brought in contact with any part of the body of the operator. The pressure slide V and both of the screens thus have their movements controlled entirely by the action of the work, and no especial attention is demanded of the workman. The dividing knife F, separates the loose piece as it is cut off, so that it cannot be caught by the teeth of the saw, and thus danger from projected blocks is avoided.

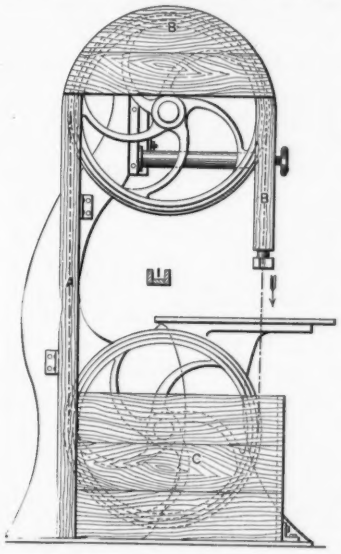


FIG. 6. GUARD FOR BAND SAW.

Band saws may be protected as shown in Figure 6, in which the idle portions of the saw are guarded by the wooden casing A B, while the lower wheel is also boxed in as at C, in order to prevent contact with the feet of the workman. Such a casing also prevents accidents due to the breaking of the saw blade, but it must be arranged so as to interfere as little as possible with the removal and replacement of the blades.

The jointing machine or hand planer consists essentially of two iron tables, between which is placed a horizontal cutter head revolving at a high rate of speed. The piece of wood is pushed over the cutter head by hand, the depth of the cut being governed by the difference in the level of the two tables. Various arrangements have been made to protect the knives. The Schrader guard is generally used in France; it consists of a curved piece of sheet iron, so arranged that it is pressed tangentially against the piece of wood, effectually covering that portion of the blades which is not beneath the wood.

Vertical moulding machines are frequent sources of serious accidents, and for these the firm of Guillet & Fils, of Paris, have designed a guard containing pressure springs which avoid the necessity of approaching the hands closely to the rapidly revolving cutters.*

In the general machine shop various special forms of protecting devices will be found in connection with lathes, planers, shaping ma-

* *Collection de Dispositions et d'Appareils Destinés à Eviter les Accidents de Machine.* Mulhouse, 1889. An abstract of this valuable paper will be found in a contribution to this subject by the late John H. Cooper, in the Transactions of the American Society of Mechanical Engineers, Vol. XII, pp. 249-264, 1890.

chines, drill presses, and other tools. These usually take the form of screens of wire netting, or of special guards arranged about the tools, but they naturally vary with local conditions and cannot be specifically described here. It will suffice to note that in France the decree of May 13, 1893, provides that children under 16 years of age shall not be permitted to operate shearing machines, or other mechanical cutting tools. The cutting machines used in paper-making establishments, binderies, printing offices, and elsewhere are frequent sources of accidents, the attendants failing to withdraw their hands in time. The best form of precaution is found in so constructing the machine that the knife rises by power and is automatically retained at the highest position, requiring the act of the attendant to cause it to descend.

Electrical Apparatus.—The Association for the Prevention of Accidents of Normandy has prepared instructions for use in connection with electrical apparatus, and these general rules, taken in connection with those of the decree of March 10, 1894, constitute the practice of the industry in France. The principal points included are briefly:

It is required that an insulating layer be placed between the base of a dynamo and its foundation. No dynamo may be placed in a situation where it may be reached by any explosive or inflammable material, except under certain regulations governing its complete enclosure in a wooden casing. Rooms containing accumulators are not permitted to be lighted by arc lamps, since the disengagement of oxygen and hydrogen may lead to an explosion. Such rooms should be provided with a powerful ventilating apparatus, and lighted by incandescent lamps only. Workmen should be provided with rubber gloves and their shoes should have insulating soles.

Switchboards must be separated from the walls of the building by an air space of not less than 8 centimetres. Connections between the dynamos and the switchboard should be insulated, but bare conductors will be permitted if supported upon porcelain insulators, care being taken to keep them at a distance from metallic masses, pipes, etc. Uncovered wires are not permitted by the French Administration for any interior wiring, and the insulated wires must be visible for inspection. This latter requirement is frequently met by placing the wires in accessible wooden conduits in the walls, if the latter are not damp. Conductors carrying a current of more than 10 amperes must be so placed that they cannot come in contact with each other.

Wiring in locations which are necessarily damp requires the use of insulators, and the work must be subjected to constant and rigid inspection. In passing through walls or sills, insulation must always

be used. The section of wire should always be proportional to the current, so that overheating may not occur to such an extent as to injure the insulation. Automatic circuit-breakers or safety fuses should be installed, to act whenever the current exceeds 10 amperes, and convenient cut-out switches should be placed where they can be readily operated.

Chemical and Metallurgical Industries.—The principal source of danger in chemical works is found in the various vats and tanks containing hot solutions, or strong acids or alkalies or other corrosive liquids. In such work, apart from any mechanical protection, the careful co-operation of the workmen is essential. The use of special forms of spectacles to protect the eyes, or of respirators and masks to guard against deleterious dust and vapors, should be required. In order to protect operatives from flying glass in the case of the breakage of retorts, these latter should be surrounded with shields of mica, while earthen vessels containing alkalies should be encased in wood.

Factories in which very inflammable substances are made, such as collodion and varnishes, also refineries for petroleum, essences, and other hydrocarbons, should require the operatives to wear special garments, consisting of a blouse coming close up to the neck and fitting closely to the wrists and body, together with trousers of similar material fastened closely at the ankles. For this purpose the woolen fabric known as "lasting" is much used in France, since this is found to ignite with much difficulty, and to cease burning when removed from the flame.

Powder mills, dynamite factories, and other establishments devoted to the manufacture of explosives are regulated very strictly in France. The following restrictions are imposed by law:—The floors are required to be covered with sheet lead. If wood is used in any case the heads of the nails must be imbedded in mastic. Frequent sprinkling and sweeping is also required. The buildings are required to be subdivided to the greatest possible extent, and between them are erected fortifications of sodded earth. In Figure 7 is shown a view of the general arrangement of the dynamite works at Saint Martin de Crau, in the Department of Bouches du Rhône, near Marseilles, giving an excellent idea of the manner in which the buildings are separated and isolated from each other. Before entering the works the workmen are rigorously inspected to see that they have upon their persons no matches, tobacco, or knives, and they are required to remove their shoes and to wear sandals. The explosive substances are worked in the form of pastes as much as possible, and in some cases they are

manipulated under water. The sieves and screens are made of fabrics containing no wire and their frames are lined with lead. All depots of powder, dynamite, fulminates or other explosives are required to be strictly separated from rooms containing electrical machinery.

In establishments for the manufacture of chloride of zinc or sulphate of iron, or in which castings or sheets of metal are pickled, as well as in works for the electrolysis of saline solutions, care should be provided for ample ventilation to remove the disengaged hydrogen and avoid explosions. Vapours of bisulphide of carbon are highly explosive when mixed with air, and great care should be taken in cases in which it is involved. At the works of MM. Deiss & Odet, in Paris, this liquid is kept beneath a body of water two metres in depth.

In the vicinity of lime kilns care should be taken against the suffocation of workmen by the disengagement of carbonic acid. In the manufacture of Javelle water or other bleaching materials a most effective ventilation is necessary to remove the fumes of chlorine.

FIG. 7. GENERAL VIEW OF THE DYNAMITE FACTORY OF THE SOCIÉTÉ ANONYME D'EXPLOSIFS, SAINT MARTIN DE CRAU.

The lead chambers used in the manufacture of sulphuric acid are required to be ventilated for 15 days before workmen are permitted to enter, otherwise they might be overcome by the nitrous and sulphurous fumes.

Explosions in blast furnaces may be prevented by providing a valve in the wind main, which may be closed at the moment when the

blast is shut off, in order to prevent the return of gas. If the outlet of the furnace is closed, the charging door should be opened when the blast is stopped.

In foundries and forges the principal source of accidents is found in the burning of workmen by molten metal or slag thrown out by agitation or local explosions. The usual protection employed in such works in France consists of a mask of wire gauze and an apron of asbestos cloth.

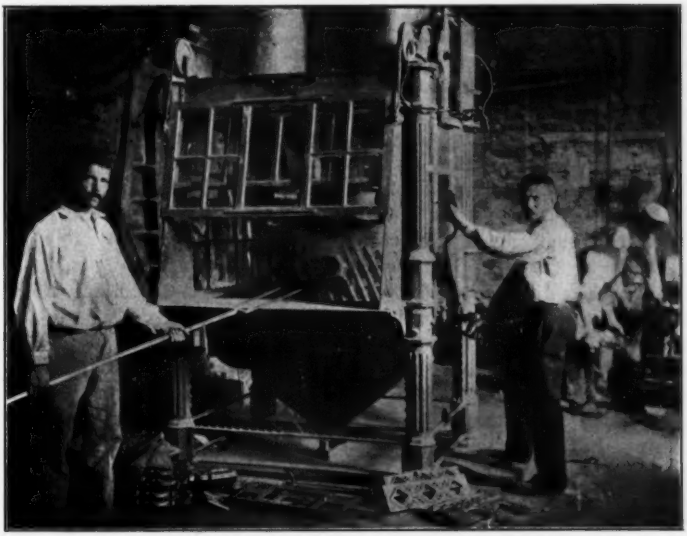


FIG. 8. WORKING OF THE MECHANICAL ENAMELLING MACHINE.

A recent example of a device for the protection of operatives is found in the improved enamelling furnace invented by M. Dormoy, director of the Sougland Works, in the Department of Aisne, for the prevention of lead poisoning of the operatives.* As shown in Figure 8, the apparatus consists principally of a case enclosed on its four sides with glass windows, of a revolving platform, and of a funnel-shaped hopper. Two sliding doors are arranged to be operated by chain gearing, so that they may be readily opened and the pieces to be enamelled introduced promptly. The windows are then closed and the pieces are exposed to the action of the furnace, the enamel being delivered through a special passage, while the fumes are carried off through the chimney.

* *Le Cosmos*, 50e Année, Nouvelle Serie, No. 845, Paris, 1901.

EDITORIAL COMMENT

GENERAL ABBOT'S convincing argument for the regulation of the Chagres by the "two-lake plan," which leads this issue, is presented under the conviction that the Panama route will be made fully available—that political obstacles will be removed as engineering uncertainties were, long since—as financial doubts have been by the recent thorough investigations. In spite of the present annoying delay, due to the lack of frankness and lack of plain common-sense in Colombia (or in her representative), our faith remains unshaken that the Panama Canal will finally be built by the United States, because it is the best, and as a nation we cannot afford—and never have been accustomed—to be content with anything but the best.

It is more than likely that Colombia misinterprets her importance in the matter, and is tempted to misuse her supposed power. There was an earlier incident in the financial negotiations which showed how far an over-grasping official could go in his dangerous folly. Fairness on the part of Colombia would beyond any shadow of question be met by not only fairness, but generosity, on the part of the United States; but greed, obstinacy, and shilly-shallying on the part of Colombian politicians should not be allowed long to delay an undertaking which is to meet an urgent need of the whole commercial world. It has been suggested that the interests of a world highway, destined for all time, would justify virtual condemnation proceedings as the effective answer to the obstinate tactics of a petty government which may go down before the work is even begun. The moral justification for such a course seems ample. Colombia's material interests in the State of Panama are at most but the shadow of a shade. Bogotá is farther from Colon in time, and farther still in directness and facilities of travel, than New York. Colombian currency is not current in Panama; Colombian postage stamps are not recognized there. The position of the United States Government shuffling on the doorsteps of the "palace" at Bogotá, seeking rights to confer an enormous benefit upon a distant and loosely-bonded Colombian state, is not pleasant.

* * *

THE alternative of dealing with Nicaragua and Costa Rica for the Nicaraguan Canal is of course the one which is loudly urged by the advocates of that route, but it would not be an event bringing much honor or dignity to our country thus to be driven from our purpose by the pettifogging of a small Central American state. And apart from the irreparable loss to the world from the adoption of the inferior route, what would be the reasonable prospect of greater satisfaction in thus putting ourselves in the power, not merely of another, but of *two* other Central American republics, with all rights and concessions, as well as a treaty, to negotiate?

The suggested "condemnation" method sounds effective, but might be difficult in international affairs. And for all practical purposes, what more is needed than the rights and concessions of the Panama Canal Company

and the Panama Railroad—which the owners stand ready to sell us, clear and unincumbered, at a price satisfactory to us—backed by our already existing powers and *obligations* to maintain free traffic across the Isthmus? Granted that there is any doubt as to the canal concession now held by the French company, this is subordinate to the railroad concession, which is not clouded by any shadow of doubt, which carries exclusive privilege of trans-isthmian traffic, and which has two-thirds of a century yet to run. If we can police, protect, and control the Isthmus for the French owners of these rights, as we have recently done, have we not all that is practically needed to ensure the same rights should we acquire them?

There seems to be one proposition which can be definitely laid down. That is, that the one "solution" the United States cannot afford to accept is the solution of accepting defeat—the "policy of scuttle"—in its undertaking to build and keep open for the world the best Isthmian waterway.

* * *

THERE appears a rather curious disposition on the part of the daily press, and also on the part of some technical journals which should be above the reproach of such a misrepresentation, to distort that portion of the report of Admiral Melville relating to the personnel bill into a statement that he does not approve of the bill. Thus, for example, so intelligent a publication as *Engineering News*, which should certainly know better, states in plain language: "He condemns the Act of Congress under which every naval officer of the line must become a fighting engineer."

We cannot let such a mis-statement go uncorrected. Admiral Melville says nothing of the sort. He says (we quote from his report to the Secretary of the Navy): "While the personnel law is correct in principle, there is a general feeling among engineers that the purpose and spirit of the measure is not being carried out," and again: "If the law is administered with a desire to make it a success, it will beyond a doubt give us the most efficient navy in the world."

Again: "In making an earnest plea for the complete administration of the personnel law" he says, "No element of personal consideration has influenced my action. I am a convert to, and not an original advocate of, the idea. I am most concerned that engineering efficiency in the navy shall not be sacrificed, and that the great fighting machines, whose motive power has been designed by this Bureau, shall not fail in the work expected of them because they are not properly cared for."

There is every evidence that all the sinister influence of the line officers, indignant that their prerogatives are invaded by the "greasy mechanics," has been exerted in an effort to pervert the public press, and to create an opinion that Admiral Melville is opposed to the enforcement of the personnel bill, while in fact any one who peruses his remarkable report will perceive that his whole contention is that the line officers should be compelled to become engineers, at the penalty of loss of promotion if detected in shirking engine-room service.

Every one who has been familiar with the "line-and-staff" controversy knows how bitter the contention has been, and how strongly the line officers have felt that the personnel bill, passed over their most determined opposition, must be nullified. No opportunity has been lost to convey the idea that the bill has been a failure, and every statement from Admiral Melville, the ablest engineer in the navy, esteemed alike for his professional attainments in naval and civil quarters, has been twisted and turned to make it ap-

pear that he is opposed to the bill. He is opposed to its non-enforcement; he is opposed to the efforts of the line officers to continue in the avoidance of engineering duties; he is opposed to all the intrigues which have been set in motion against the bill; but he is fully convinced that "every officer on a modern war-vessel has to be an engineer, whether he wants to or not."

* * *

ON October 20 last the Düsseldorf exposition was officially closed with appropriate ceremonies, and it is extremely gratifying to be able to comment upon the conduct of the enterprise as one of the most successful expositions yet held in any country.

While the conditions and character of the exposition render it impossible to make satisfactory comparisons with the great international exhibitions, such as those at Paris or at Chicago, yet size is not the only element to be taken into consideration. The Düsseldorf exposition was notable for at least two things, apart from the brilliancy of the exhibits and the effectiveness of the structures: it was fully ready on the opening day, and it more than paid all its expenses!

The official report of attendance showed 3,056,627 paying visitors, making, with the entrances of the exhibitors and attendants, a total of 4,882,459, while the receipts amounted to 3,184,355 marks. The entire guarantee fund was repaid, with interest, with an estimated surplus of a quarter of a million marks.

Of the technical and industrial importance of the exposition this is not the place to speak at length, since a full account appeared in our October issue, and all the important papers published elsewhere are recorded in the Engineering Index; but its influence upon the development of the engineering industries of the Rhine provinces of Germany cannot fail to be for great and lasting benefit.

A CURIOUS criticism recently reached us with reference to the various papers on works organization and factory accounts which have appeared from time to time in our pages. It was complained that these papers were in many cases so abstruse that they required careful studying; that, in fact, it was necessary to sit down in a quiet place and give considerable attention to the subject matter of the papers before their teachings could be thoroughly grasped.

It is difficult to know how to reply to a complaint of this kind, if it is to be treated seriously. How can the presentation of a subject of extreme complexity be other than complex in itself? The Greek philosopher told his royal pupil that there was "no royal road to mathematics." In the same way we might say there is not, and, from the nature of the case, cannot possibly be, any short cut, or journey by easy stages, on the path of modern works organization. The old days when the operations of the largest works could be adequately recorded with a memorandum book and pencil have gone for ever. In their place we have to provide for the registration of the work not only of hundreds of individuals, but of individuals so grouped, and engaged in work so diverse, that systematic integration and analysis is necessary to make the results intelligible and significant.

While sympathizing, therefore, with those old-fashioned persons who look back with a sigh upon the simpler days of their youth, and grumble at the trouble it is necessary to take to grasp the principles of these complex modern systems, it is difficult to see how they can be offered any encouragement. The tendency unquestionably is for manufacturing units to become larger, and in accordance with the law of evolution, more highly specialized and complex in their internal arrangements.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

NAVAL ENGINEERING IN AMERICA.

VITAL FEATURES IN THE DEVELOPMENT OF MODERN NAVAL POWER FROM AN ENGINEERING STANDPOINT.

Report of Rear Admiral Melville.

ONE of the most interesting features about naval development in the United States is found in the system whereby the heads of the various bureaus embody the results of their work with their recommendations and opinions in reports which are printed and freely given to the public. There is probably no other government in the world which permits such publicity in its workings as the Navy Department of the United States, and so far as the practical working of the system is concerned, this freedom of utterance is to the manifest benefit of the service.

Among the various interesting subjects treated in the report of Rear Admiral Melville, the Engineer-in-Chief, we notice especially the recommendations for an experimental engineering laboratory in connection with the Naval Academy at Annapolis. This is a matter which has been urged for several years past, and it is to be hoped that it will receive successful consideration at the hands of the coming Congress.

In urging the establishment of such a laboratory upon the Department, Admiral Melville says:

"Any naval service which is not kept in a state of efficiency has no reason for its existence. It is therefore the desire of naval officers as well as of the administrative officials of the Department to keep the ships ready for immediate service, and this can only be done by anticipating and providing for casualties and deterioration. The material that is now used in the construction of engines and boilers is of very high order. As in the case of a thoroughbred animal, its nature and qualities must be thoroughly understood, otherwise there is rapid decline. Desultory study upon the part of individuals is of course desirable, but systematic research and experiment can only bring about the best means of procuring good material and appliances and maintaining them in the highest possible state of efficiency."

In further emphasis of the importance of the question he enumerates several problems upon which reliable experimental information is needed, and which such a laboratory could supply, namely:

(a) The best means of utilizing liquid fuel for naval and maritime purposes. The naval power that can successfully install a liquid-fuel plant in a war ship will possess a great military advantage. It is not at all improbable that the liquid-fuel problem will have a very important effect in determining which nation shall possess the carrying trade of the world.

(b) The value of the steam turbine for naval purposes. The British Admiralty regard this subject of vital importance, and the success achieved with the torpedo-boat destroyers and with several merchant ships installed with this appliance warrant increased attention being given this matter. While it is true that the two torpedo boats of this type which were built for the British navy were short lived, the boats came to grief through no fault of the machinery.

(c) The best form and size of propellers; their location with reference to the keel and sternpost; the character and area

of the blades. The experience of the various torp do-boat builders dur ng the past five years conclusively shows the necessity of extended investigation of this subject. The tests made by the Bureau twenty-five years ago in regard to propellers are still regarded as valuable, and urgent requests have been made that more experiments of this nature be conducted.

(d) The value of electricity as a prime mover for naval purposes. In the United States Navy the use of electricity is more extended than in that of any other service. Its endurance for naval purposes has been seriously questioned by others. Systematic tests and experiments would undoubtedly afford valuable information upon disputed points. It is pertinent to state that, while electricity has been used for operating winches, ammunition hoists, fan blowers, and other appliances, the steam capstan in the bow and the steering engine in the stern have still long lines of steam piping leading to these appliances. It is also somewhat paradoxical that the ice machine is still operated by steam, so that we have the anomaly of the cooling tank of this appliance condensing the steam and the steam in turn melting the ice produced. Illustrations of this kind show that considerable more study can yet be given the question of installing electric motors on board ship.

(e) The corrosion of boiler and condenser tubes. The rapid deterioration of boiler and condenser tubes, as already stated, seriously decreases the engineering efficiency of the modern war ship. The Bureau has made some important tests in connection with this matter, but the necessity for further investigation and experiment is exceedingly apparent.

(f) The best form and type of water-tube boilers for naval purposes. There are military and technical reasons why our navy should soon settle upon an approved type of boiler, and this design should, if possible, be one which is a development of a type used extensively on shore. There are so many factors that will interfere with boiler efficiency that extended experiments are necessary to secure reliable information upon the subject. In the investigation of this question a large appropriation could be profitably expended. During the past three years the British navy has expended hundreds of thousands of dollars in conducting comparative tests of different forms of boilers. While our navy has received valuable information from this source, it is exceedingly probable that information has been secured by the Admiralty which has not been given to the world at large.

(g) The possible advantages resulting from more extensive use of compressed air as a motor. Particularly at navy yards, and even upon repairs to ships in commission, a more general use of compressed air could be advantageously employed. Now that the water-tube boiler is coming into more general use in all navies, it is exceedingly probable that it will be necessary to use compressed air for properly cleaning these steam generators.

(h) The balancing of marine engines. There is a progressive tendency to increased piston speed, and with each succeeding year the necessity for more perfect balancing becomes necessary.

(i) The development of the storage battery for marine purposes. The discovery of a storage battery of decreased weight, but of increased endurance, will greatly add to the efficiency of the modern war ship. The fact should be conclusively established whether or not the gases generated can accumulate and produce explosions that will seriously injure the ship or impair important mechanical appliances.

(k) The perfection of a more reliable and efficient gas engine. The danger attending the use of this motor now makes it inadvisable for extended use in the navy.

(1) Extended investigation as to the best forms of steam, hydraulic, and pneumatic joints. By reason of the development of the water-tube boiler and the tendency toward increased steam pressure there has been considerable trouble experienced in keeping the joints tight. The delay and annoyance from such impairment may result in engineering inefficiency.

In spite of the limited opportunity available for experiments under existing circumstances the Bureau has been able to make some very interesting experiments upon oil fuel for marine boilers.

These tests have been made not only upon the steamship Mariposa, in the course of a run from San Francisco to Tahiti and return, and also upon an experimental water-

tube boiler at Washington, and the results are of the utmost value to the engineering profession at large. In fact the report of the liquid-fuel board is itself an excellent example of the wisdom of the publicity which has been given to its work. Thus we read the following in the report of the board:

"The board is of the opinion that the best interests of the Navy will be subserved by making public at this time the data and information collected during fourteen official experiments that have been conducted. There are many persons outside of the naval service who are interested in the subject, and who would cheerfully render assistance along special lines if they could secure a knowledge of the general purpose and work of the board. These engineering experts in the mercantile marine, as well as in civil life, will in return obtain trustworthy information from the data secured, and thus be able to make important deductions. The benefit of submitting a preliminary report will thus redound to the material advantage of all interested in the development of the use of liquid fuel whether or not they are connected with the naval service."

We have space here only for the conclusions thus far reached by the board, but recommend all interested to study the details in the report.

"The following information has undoubtedly been secured:

(a) That oil can be burned in a very uniform manner.

(b) That the evaporative efficiency of nearly every kind of oil per pound of combustible is probably the same. While the crude oil may be rich in hydrocarbons, it also contains sulphur, so that, after refining, the distilled oil has probably the same calorific value as the crude product.

(c) That a marine steam generator can be forced to even as high a degree with oil as with coal.

(d) That up to the present time no ill effects have been shown upon the boiler.

(e) That the firemen are disposed to favor oil, and therefore no impediment will be met in this respect.

(f) That the air requisite for combustion should be heated if possible before entering the furnace. Such action undoubtedly assists the gasification of the oil product.

(g) That the oil should be heated so that it could be atomized more readily.

(h) That when using steam higher pressures are undoubtedly more advantageous than lower pressures for atomizing the oil.

(i) That under heavy forced-draft conditions, and particularly when steam is used, the board has not yet found it possible to prevent smoke from issuing from the stack, although all connected with the tests made special efforts to secure complete combustion. Particularly for naval purposes is it desirable that the smoke nuisance be eradicated in order that the presence of a war ship might not be detected from this cause. As there has been a tendency of late years to force the boilers of industrial plants, the inability to prevent the smoke nuisance under forced-draft conditions may have an important influence upon the increased use of liquid fuel.

(j) That the consumption of liquid fuel can not probably be forced to as great an extent with steam as the atomizing agent as when compressed air is used for this purpose. This is probably due to the fact that the air used for atomizing purposes, after entering the furnace, supplies oxygen for the combustible, while in the case of steam the rarefied vapor simply displaces air that is needed to complete combustion.

(k) That the efficiency of oil fuel plants will be greatly dependent upon the general character of the installation of auxiliaries and fittings, and therefore the work should only be intrusted to those who have given careful study to the matter, and who have had extended experience in burning the crude product. The form of the burner will play a very small part in increasing the use of crude petroleum. The method and character of the installation will count for much, but where burners are simple in design and are constructed in accordance with scientific principles there will be very little difference in their efficiency. Consumers should principally look out that they do not purchase appliances that have been untried and have been designed by persons who have had but limited experience in operating oil devices."

The question of the personnel bill and its influence on the future of the naval service forms an important feature in the report, and comment upon it will be found elsewhere in this issue.

THE DIFFICULTIES OF ENGINEERING STUDENTS.

TECHNICAL TRAINING FROM THE VIEWPOINT OF A STUDENT OF ELECTRICAL ENGINEERING—PRACTICAL VALUE OF THEORETICAL INFORMATION.

Correspondence in the Electrical Review.

WE have given much space of late in these columns to the important subject of technical education, believing that it rightly lies at the foundation of manufacturing and commercial supremacy. The discussions which we have reviewed, however, have all been papers of professional instructors and scientific men, of teachers; thus dealing really with but one side of the question. For this reason it is most interesting to note a communication in the *Electrical Review* from a student of electrical engineering, evidently anxious to acquire knowledge which will serve him in the subsequent practice of his profession, and encountering many difficulties by the way.

Taking the author of the article noted at his own definition, "an average, hardworking, industrious student, who is trying his very best to get on with the brains at his disposal," we find his principal difficulties may be summed up very definitely. In the first place he meets the usual query of students in nearly every line of work, a doubt as to the practical value of much that he is obliged to study. In this he notes the difference between the study of engineering and of medicine, the embryo physician realising at once that all he learns he will subsequently need to know. There is not so much in this objection, however, as at first appears, since the analogy between the two professions does not hold very far. In nearly every case the doctor practices his profession alone, that is, he visits the patients himself, performs the operations with his own hands, unless assistance is absolutely necessary, in fact, the higher he rises in his profession the more important does his own personal manual skill become. With the engineer the development leads rather to the relinquishment of detailed work to other hands, so that while he may commence with the making of drawings and the execution of shop work, he must expect, if he is to attain any measure of professional success, to delegate this work to subordinates, and to devote himself ultimately to just those departments of his profession which involve the things which appeared so unnecessary to him in his student days. He may rarely, if ever use the calculus in his personal work, using either the fully tabulated work of previous investigators, or possibly relegating all such work to a "tame mathematician" in a back office, but unless he has learned how to think with the logic of mathematical conceptions he will find it impossible to grasp the ideas which his growing work involves.

Again the student fails to see the combination between theory and practice, and his failure to grasp this relation naturally leads him to think that the trouble lies with his teachers and their methods, rather than with himself. Sometimes it does lie with the teacher, and often, far too often, the professor has never had the practical experience at all, having developed from the class room, through the stages of assistant and instructor, to the heights from which he attempts to impart knowledge of that practice which he knows but at second hand, or even further removed. At the same time the student must remember that he begins his practical training as he is completing his theoretical instruction, and hence the higher stages of the latter meet the elementary beginnings of the former, so that there is small wonder that the direct connection is not readily perceived.

It is altogether true that the relation between theory and practice is not readily acquired in the shop, since the shop workmen as a rule know nothing of the reasons involved in the work which they are doing, while at the same time they may be very well acquainted with the proximate causes of the effects under their immediate observation. At the same time the student who knows the theory of the shop operations, while he may not be able to connect the relations at once, will gradually find that there is a close relation, and having found this out he will make a progress far exceeding in rate that which he could have made without a correct understanding of

the theory. That he should have to work some of these things out for himself, may well be laid to the limited time available for instruction, but it can surely not be made a reason for curtailing the study of theory.

In one feature the student's commentary on courses of training is most timely, namely, in regard to the desirability of providing some instruction upon the important subjects of works management and the commercial side of the profession. A short and practical insight into the very necessary commercial branch of his profession should certainly be given to the engineering student, since experience has shown that it is in this very department that existing manufacturing establishments are most deficient. At least the student should know the essential principles which constitute efficiency in manufacture and works management, a little about some system of standardisation in manufacture, so as to enable a large number of machines of the same class to be manufactured cheaply and quickly, a little about the law governing the relations between the employer and his workmen, and also a few gleanings from the patent laws, so as to be able to protect himself in any eventuality.

This whole paper is interesting, quite as much for what it fails to say as for what it sets forth. There is no doubt that modern educational institutions have many deficiencies, and that these are mainly in the field of fitting the student for his immediate practical work. At the same time it must be understood that the student himself has but vague ideas as to what his practical work really will be. It is far more important for him to be so thoroughly grounded in fundamental principles that the error in any fallacy shall strike him promptly and forcibly than that he should be able to set a lathe tool or wind an armature. It is even more important that he should be able to gather some isolated facts and state them in the form of a concrete question than to be able to solve that question after it is stated. He can find many ways of solving problems after he has got them clearly and logically placed before him; many students who can solve book problems most glibly never succeed in stating any practical questions whatever thereafter.

It is most definitely understood that nearly all progress in any branch of industry has been made by the intrusion of rank outsiders, men who have not gotten so deep into the ruts of practice that they cannot look over the sides of the cañons in which they so contentedly travel, and our dissatisfied student may well be thankful that he is given a chance to approach his work freed from the trammels of old established practice, while at the same time equipped with an unchangeable foundation of sound theory.

All these evidences of unrest in matters educational are most encouraging, and when we see professors and students alike discussing educational problems on their merits we cannot but feel cheered in the conviction that the doom of mediæval scholasticism is approaching and that the spirit of honest searching after truth is yet alive.

THE STORAGE OF CONDENSING WATER.

REGULATION OF CONDENSING WATER SUPPLY TO CONFORM TO THE FLUCTUATING REQUIREMENTS OF WIDELY VARYING ENGINE LOADS.

F. J. Weiss—Verein Deutscher Ingenieure.

MODERN steam engineering has so fully realised the importance and value of the condensation of exhaust steam that nearly every large power plant is placed where it can secure a supply of condensing water. Where such a supply is ample no especial provision need be made other than proper pump capacity. In most instances, however, the supply of condensing water must be handled with care, and even where great economy of water is not necessary, the regulation of the amount should be made to conform to the demand.

The general use of various forms of ejector and gravity condensers, in which the maintenance of an unbroken flow is important renders this question one which the engineer should be prepared to handle, and hence the exhaustive paper by Herr F. J. Weiss, in recent issues of the *Zeit-*

schrift des Vereines Deutscher Ingenieure, upon accumulators for condensing water, is of present interest.

The method adopted by Herr Weiss is an ingenious one, forming, as it does, a sort of hydraulic fly wheel by furnishing an intermediate reservoir of condensing water and regulating the flow according to the demand. The arrangement varies according to the form of condenser but in general it consists of a water tank, so placed that a portion of the water is intercepted on its way to the discharge, and returned to the condenser to be used a second time. By providing a tank of sufficient size there will be enough water stored to meet any sudden demand, while when the demand is lessened the stored supply will not be drawn upon, but will cool and be held ready for service.

Herr Weiss examines the theory of this system of stored water for gravity condensers at length, taking into account the heat stored in the water during the periods of heavy loads on the engine, showing that with such a storage tank the average supply may be maintained without risk of impairing the vacuum at any time. It is therefore rendered possible to use the minimum supply of water and at the same time be sure of a good vacuum, an important feature both from the standpoint of pumping economy and limited water supply.

In this connection we may call attention to the extent to which condensation is used in modern power plants. The old idea, in the United States especially, was that condensation was only advisable in the case of large engines, operating under fairly uniform loads, this following closely upon the pumping engine practice of Great Britain. The burden of air pump and cold water supply was thought to form too large a proportion of the total load for small engines to render condensation advisable, and high pressure was the rule. Within comparatively recent times, however, the idea of the central condensing plant has been introduced, this involving the maintenance of a single condensing and air pump system for all the steam machinery in an establishment. There is then a combination of a positive pressure system, the boiler plant, and a negative pressure system, the central condenser plant, the cylinders of all the engines, pumps, and other steam motors standing between them. This arrangement is an ideal one for the large power plant containing as it does engines, pumps, and steam machinery of all sizes and kinds. However variable the load may be upon the various engines, the exhaust discharge of all of them will be close to the average, so that a uniform water supply and a constant speed of air pump will serve to maintain a fairly constant vacuum economically.

The importance of a good vacuum is especially to be considered for the small engines in a plant, which are necessarily of low economy in any case, and consume a large proportion of the total amount of steam generated. On shipboard the low economy of the auxiliaries has been partially compensated by allowing them to exhaust into the receiver space, their cylinders thus acting as high-pressure cylinders in a compound system of which the low pressure cylinder of the main engine forms the continuation.

THE SPONTANEOUS COMBUSTION OF COAL.

NATURE, CAUSES, AND METHODS OF PREVENTION OF SPONTANEOUS COMBUSTION OF BITUMINOUS COAL.

Recent Experiences in France.

ONE of the difficulties which has always been encountered in the handling and storage of soft coal has been the liability to spontaneous combustion. In the mine this has been a not infrequent source of mine fires, while on shipboard it is always a cause for anxiety to engineer and captain, and the same question must be met when large quantities of bituminous coal are stored in the yard, on the dock, or elsewhere.

The valuable paper of Commander Caborne upon this subject was reviewed at length in these columns last February, and now we have the important series of papers by M. J. Abadie, in recent issues of *Le Génie Civil,* discussing in general the causes of fires in mines, and giving some valuable

results of experiences with spontaneous combustion in the mines of the Decazeville district, in the Department of Aveyron, in the south of France.

In view of the fact that by far the greater portion of all the coal available for use is of the bituminous variety, and that it must naturally displace anthracite before many years, it is most important that the causes and methods of prevention of spontaneous combustion be fully understood, and hence we abstract that portion of M. Abadie's paper which treats of the subject.

Broadly speaking, the fundamental cause of spontaneous combustion is oxidation, and it is therefore originally due to the admission of air to the interior of the mass. In the mine this may take place by reason of the breaking down of portions of the seam, crushing the coal and permitting the infiltration of air, but in the case of mined coal the admission of air is a matter which may be more effectively controlled.

In order that the oxidation may proceed rapidly enough to generate heat sufficient to ignite the coal, there must be an ample supply of air and free opportunity for contact. On the other hand if the circulation of air throughout the mass be sufficiently high it will act to carry away the heat and thus cool the coal, so that in many instances the oxidation will not cause the temperature to rise to the igniting point. It is this fact doubtless, which has caused so many contradictory statements to appear as to the effect of ventilation upon spontaneous combustion.

The presence of pyrites was formerly considered to be the principal element in the spontaneous combustion of coal, but this is now known not to be the case, although it is doubtless true that the presence of a quantity of iron pyrites in the presence of air and moisture may aid in the generation of heat. This question of the presence of moisture is especially important when pyrites are present, but otherwise it does not appear to influence the heating of the coal.

A very important element in the furtherance of spontaneous combustion of coal is the temperature of the surrounding air. It is now well understood that a very moderate increase in the temperature of surrounding bodies is sufficient to increase very greatly the rate of oxidation and thus to promote the further rise in temperature of the coal to the ignition point.

Thus in mines the heat of underground workings, and especially the approach to older burning measures, may suffice to produce spontaneous combustion when it had previously not been anticipated.

The same is true on shipboard, and the greatest care should be taken to prevent the running of lines of steam pipes close to the coal bunkers, and to avoid the arrangement of coal storage close to the shells of the boilers.

Since spontaneous combustion of bituminous coal, therefore, is due to oxidation, the first precaution to be taken is to prevent access of air to the mass. This can generally be effected more or less completely on shipboard, or in mines, and hence its importance should be appreciated. The avoidance of external heat should also be considered, and it is probable that this has not received proper consideration on shipboard, where too often the pipes are run without due regard to the effect upon the surroundings.

The influence of the introduction of air into the mass of coal has been clearly shown by the experiments of M. Fayol. Thus a cask of bituminous coal was so arranged that a thermometer, with its bulb placed in the centre of the mass, could have the temperature read upon its projecting stem. The cask was arranged with numerous holes above and below so that the admission and circulation of air through the mass could be regulated at will. Numerous experiments with this simple apparatus showed that with the admission of air the temperature rose until a maximum was reached, after which further admission of air caused the temperature to fall. This clearly proved that there is a point beyond which the air carries off the heat faster than it can be generated. At the same time the practical impossibility of insuring such a complete ventilation throughout the entire mass of the coal renders it impracticable to use this idea for keeping the coal cool, since any point insufficiently ventilated might reach the ignition temperature, and thus set fire to the whole mass.

The methods to be followed to extinguish a fire in the body of a mass of coal naturally differ somewhat from those for ordi-

nary fires. All access of air should be cut off as completely as possible, and where this can be effectively done the exhaustion of the supply of oxygen must soon follow. The heat remaining in the mass however, will cause immediate ignition upon opening the compartment, hence ample time must be allowed for cooling. On shipboard it is wise to provide some special apparatus for fighting fire in the bunkers, the most effective forms being those which operate by the forcing of some suitable gas into the burning mass. Usually carbonic acid gas is used for this purpose, but Commander Caborne advises the employment of sulphur dioxide, readily produced by burning sulphur in the open air, and delivering it into the bunkers by a blower.

THE SPEED OF ARMORED CRUISERS.

A DISCUSSION OF THE POWERING AND ARMOR-PROTECTION OF THE AMERICAN CRUISERS TENNESSEE AND WASHINGTON.

Reports of the Board on Construction.

MUCH interest has been exhibited in engineering circles in the discussion regarding the disposition of the weights in the new cruisers authorized by Congress, and known officially as Nos. 10 and 11, to be named when completed, "Tennessee" and "Washington."

The Board on Construction, to which the details of the new vessels are intrusted, consists of the Chiefs of the Bureaus of Ordnance, of Steam Engineering, of Construction and Repair, and of Equipment, together with the Chief Intelligence Officer. The question upon which the discussion has taken place in this board may best be understood by reference to the majority and minority reports, the latter having been made by the Engineer-in-Chief, Rear Admiral George W. Melville, U. S. N., Chief of the Bureau of Steam Engineering, which Bureau has in charge the design and construction of the engines and propelling machinery.

The cruisers under construction were limited by Congress to a "trial displacement" of 14,500 tons, but upon the presentation of the plans for the vessels and their machinery to the board by the various bureaus it appeared that the total of the weights exceeded this amount by 70 to 80 tons. At the same time it was proposed by the board to increase the weight of armor, so that the total excess reached nearly 200 tons.

Two methods were proposed to reduce this excess in weight, one being to diminish the thickness of armor and weight of armament, and the other to reduce the power of the engines. In the majority report, signed by all the members of the board except Admiral Melville, it is stated that 190 tons, the amount to be saved, represents 35.7 per cent. of the total weight of the battery, and 7.2 per cent. of the total armor protection. If this same amount is taken from the weight of the machinery it would require the power to be diminished from 25,000 to 23,000 horse power.

It is maintained by Admiral Melville that such a reduction in powering will reduce the speed from 21.5 knots to 20.9 knots, this being based upon the fact that the total displacement when the ship is in commission and ready for sea will be more than 16,000 tons.

The majority report, considering only the trial displacement of 14,500 tons, maintains that a speed of 22 knots can be secured with 23,000 horse power, this opinion being based upon experiments made in the model testing tank at the Washington Navy Yard, but Admiral Melville calls attention to the fact that trials upon small models cannot be depended upon to such a close margin, he preferring to be governed by the actual performances of vessels already constructed and possessing the same size and fineness.

As to the importance of speed in armored cruisers, Admiral Melville makes some very pertinent remarks, and in view of the fact that Congress stipulated that the proposed vessels should have the "highest practicable speed" we may quote from his minority report: "I cannot believe that Congress did not intend that these vessels should be equal to or superior to any of their class, that class being armored cruisers, and not battleships where very high speed may not be so essential; and I am not at all certain

that an extra knot and the additional power for it should not have been insisted on in the first place."

In considering the class to which the proposed cruisers belong comparison is made with the "Drake" class in the British navy. These vessels are 500 feet in length; 71 feet beam, and draw 26 feet at a displacement of 14,100 tons; in other words they are 2 feet shorter, 1 foot 10½ inches less beam, 1 foot more draught, and 400 tons less displacement than the "Tennessee" class. On the other hand they are of 23 knots speed, and are given 30,000 horse power, or a full knot more speed and 5,000 more horse power than was even proposed for the "Tennessee," and so can engage with or avoid the latter ship at will. The protection of the "Tennessee" is claimed to be much better distributed than that of the "Drake," and her main battery is much heavier, but this is to a great extent offset by her great inferiority in speed, which places her at the very great disadvantage of not being able to use it unless the faster vessel permits it.

Admiral Melville frankly states that he does not believe that 23,000 horse power will give the vessels of the "Tennessee" class a speed of 22 knots, and this belief is based on the performance of similar ships. The "Drake" class are of 400 tons less displacement and have finer lines, and it required about 23,000 horse power to give them a speed of 22 knots on their trials. The "Gambetta" class, in the French navy, is to have 27,500 horse power to make 22 knots on 12,416 knots displacement. From this it would appear that 25,000 horse power is a very moderate estimate of the power required to drive a ship of 14,500 tons displacement 22 knots, and an armored cruiser of that size that cannot make it cannot be considered an up-to-date, first-class ship.

Although Admiral Melville is in the minority, so far as the board is concerned, there is little doubt that his views are sustained by the great majority of engineers who are qualified to judge in the matter. The question of speed is a vital one for a cruiser, and any increase in armament at the expense of speed simply results in transferring the vessel to another class. If battleships are desired that fact should be considered from the first, but if cruisers are intended it is cruisers which should be built. Especially is it important that the full displacement of the vessel when in commission should be taken into account in the powering. Trial displacements are as fictitious as trial speeds, and neither play any real part when the cruiser is in action or in service. The behaviour of the Oregon in the chase at Santiago brought out most emphatically the surprise of all at the fact that a vessel should ever after equal her trial speed, and it seems altogether senseless to specify a speed under conditions which can never afterwards be reproduced. It is to be hoped that trial speeds may some day be relegated to the limbo to which "nominal" horse power has long since gone, and that men who, like engineers, are accustomed to precison in all other forms of measurement, may treat the speed of a ship with the same degree of accuracy as they do many other things of infinitely less importance.

ELECTRIC RESPONSE.

A STUDY OF THE PERCEPTION OF SENSATIONS IN VARIOUS FORMS OF ORGANIC AND INORGANIC MATTER.

Prof. Chunder Bose, before the British Association.

THE excellent work which has been done during several years past by Professor Jagadis Chunder Bose, in connection with the production and reception of electric waves is well known. The results of a portion of his researches were presented to the Royal Society last summer, and following these communications comes a most interesting demonstration before the British Association at its recent meeting at Belfast.

Broadly, the work which Professor Bose has undertaken is to show the relation between molecular and electrical disturbances. It is well known that when a body is subjected to mechanical stress there is a corresponding mechanical strain produced. Professor Bose shows that this is also ac-

companied with some form of electrical disturbance.

Apart from the interest which these experiments have aroused in scientific circles, they have also attracted a popular curiosity in that they tend to show that all substances, organic and inorganic, possess some degree of sensibility, thus suggesting a continuous connection between the organic and inorganic world.

The details of some of Professor Bose's experiments form very interesting reading, but a full conception of their meaning can be obtained only by a careful study of his published papers.

We may, however, give a general idea of the apparatus employed, together with a brief account of some of the results.

The simplest form of apparatus consists of a metal rod, of which two points are connected with a galvanometer by means of non-polarisable electrodes. If this bar is struck between the connections to the galvanometer, there will be produced a wave of molecular disturbance. If any electrical disturbance is also produced, it cannot be shown under these circumstances, since the wave will be sent out through each electrode, and they will balance each other and produce no effect upon the galvanometer needle. If, however, some means can be found of checking, or otherwise affecting the wave in one or the other direction, this balance will no longer exist, the galvanometer will be affected, and the difference between the two waves will appear.

Two methods have been found for producing intelligible results. One of these is called the method of "block," and may be considered as a mechanical operation. Thus, if a clamp be placed upon the wire, between the point struck and one of the electrodes the wave will be hindered from reaching one electrode, and a momentary swing will appear upon the needle. By using a mirror galvanometer and receiving the moving spot of light upon a travelling band of sensitised paper, the actions will be recorded as curves.

The second method employs chemical action to deaden or exalt the sensibility of one portion of the rod or wire. Thus if a portion of the rod be moistened with distilled water, or with dilute solutions of sodium chloride, potassium bichromate, etc., no effect is produced, while some reagents enhance the electrical excitability, and others again, depress it. Thus when one portion of the rod is moistened with sodium carbonate, that portion will be found more excitable than before, and a stimulus given to the rod will affect the moistened end to a greater degree than the other portion, and a corresponding deflection of the galvanometer will appear. If, however, a solution of oxalic acid is used, a depressing action will be observed, the current flowing in the opposite direction upon the application of stimulus.

Professor Bose gives a number of experiments showing interesting variations upon these lines, all tending to show that mechanical disturbances are accompanied by corresponding electric waves, and that this action can be modified by stimulating or deadening substances in a very definite manner. In other words materials which are undoubtedly inorganic, and in the common parlance altogether "dead," are capable of responding to external stimulus, and thus possess, to a certain extent, perceptions of sensation similar to those of living matter.

In order further to study the analogy between this electric response in inorganic matter, and the perceptions of living things, Professor Bose has conducted a series of experiments showing precisely similar actions in living tissues. The effect of stimulus upon motile tissues, it is true, causes a change of form, but upon the nerves, for example, no change of form follows, although a distinct response is produced. The excitation of the tissue may, however, be detected by a certain electromotive change, and in this respect the behaviour of nerve tissue is similar to that of the inorganic rod already discussed.

Electric response is a measure of the physiological activity of the tissue. When the physiological activity is exalted by a stimulant, the electrical response will rise in amplitude. When the activity is diminished, as by narcotics, the electrical response is also diminished, and when the tissue is killed the electrical response disappears altogether. Ordinarily these response phenomena have been regarded as due to some super-physical "vital" force, but this conclusion is not justified, since the response

processes seen in life correspond closely to those foreshadowed in non-life.

On account of the wideness of the gap between animal and metal, Professor Bose undertook experiments upon the intermediate world of plant life. The analogy was shown to be remarkably close. Response was obtained in all plants and by all their organs. When the plant was killed by poison or by hot water the electrical response disappeared. The responses in plants and in metals were shown to be modified exactly in the same way as animal tissues are modified, there being not a single phenomenon in the response in muscle and nerve that has not an exact parallel in the response of metal and plant. Just as the response of animal tissues is found to be exalted by stimulants, lowered by depressors, and abolished by poisons, so also it is found that under the action of appropriate reagents the response in plants and metals undergoes similar exaltation, depression, or abolition.

The conclusion reached by Professor Bose, therefore, is that: "Irritability or capacity for response is not confined to living tissues. The living response in all its diverse manifestations is but a repetition of the physical phenomena exhibited by the inorganic. There is in it no element of mystery or caprice, as is admitted on the assumption of a hypermechanical 'vital' force, acting in contradiction or defiance of those physical laws which govern the world of matter. Nowhere in the entire range of these response phenomena—inclusive as that is of animals, plants, and metals—is there any breach of continuity. The response phenomena are not determined by the play of an unknowable and arbitrary vital force, but by the working of laws that know no change, acting equally and uniformly throughout the organic and inorganic worlds."

SMOKELESS COMBUSTION OF BITUMINOUS COAL.

SCIENTIFIC CONSTRUCTION OF FURNACES AND CORRECT CONDITIONS OF COMBUSTION. BRITISH AND AMERICAN EXPERIENCES.

An International Symposium.

EVER since the introduction of steam power attempts have been made to provide for the smokeless combustion of coal, and while the problem has been studied by able engineers from the time of Watt to the present, there is little doubt that the smoke question is daily becoming more pressing. In England, where all the coal used both for industrial and household purposes is entirely or partially bituminous, the subject has long been a matter for consideration, and the same has been true of Pittsburg and other cities in the United States in which soft coal is used. Until recently, however, a number of the large cities on the Atlantic coast of the United States have been free from the annoyances and discomforts of soft coal smoke and it is only by reason of the prolonged labor troubles in the anthracite coal districts of Pennsylvania that the use of bituminous coal in New York, Philadelphia, and other cities has called attention to the fact that the supply of anthracite must be considered as limited and irregular, and that the sooner the smokeless combustion of bituminous coal becomes the rule, the sooner the dominating power of a limited territory under the control of a few people, over the comfort and purse of the public will be terminated.

The supply of bituminous coal in the United States at least, and in Asia, is practically unlimited, and when it is properly burned it offers no difficulties or inconveniences, while at the same time its excellent calorific power renders it entirely satisfactory so far as steaming is concerned.

Among recent articles on the subject of the smokeless combustion of bituminous coal we note the excellent paper of Mr. W. H. Booth, presented at the Belfast meeting of the British Association, the exhaustive series of papers by Mr. Albert A. Cary, in late issues of the *Iron Age*, the communication of Mr. T. T. Parker, in the *American Machinist*, and various other articles, all bearing upon features of the problem.

These papers, while differing in their treatment of the subject, all agree in emphasising the one fact that the usual appliances for burning bituminous coal in

practice are constructed with entire disregard of the true principles of combustion.

Thus Mr. Booth says: "Engineers are taught at college that combustion can only take place in the presence of a sufficient supply of oxygen at a sufficiently high temperature. An ordinary class-room experiment is to surround a candle flame with a coil of wire, which abstracts heat so rapidly from the flame as to cause combustion to cease, and the flame is extinguished. This experiment contains the whole secret of combustion. When engineers go out into the world, they find that the burning of coal and generation of steam are carried out upon lines which are quite opposed to the principles they were taught at college, and more upon the lines of the refrigerated candle-flame experiment. They become aware that the daily practice of steam raising, while opposed to theory, is very far from good, and they are told that it is not possible to burn bituminous fuel except with evolution of smoke. Most engineers acquiesce in this very lamentable state of affairs, and are the more inclined to do so, because, where teachers of engineering have been responsible for boiler arrangements, they are unable to find that these present any differences from the common herd. The modern steam boiler is, in fact, quite as primitive as a common pan set directly upon a fire to boil. An African savage, with a gourd as his pot, places this to boil just as scientifically as do our professors of engineering place boilers. The modern boiler maker merely sells boilers. The consulting engineer, who ought to order their setting, accepts the methods of the savage, the impossibility of which, in respect of good results, he has taught, or has been taught at college, but has not comprehended."

Mr. Cary fully agrees with this position, saying:

"The smoke nuisance from boilers can be almost entirely avoided by the adoption of proper furnaces adapted to the fuel used and by the employment of a sufficient amount of intelligence to handle the fires properly. The whole secret of burning fuel smokelessly is to obtain complete combustion in the furnace and combustion chambers before any appreciable amount of the combustible gases meets the chilling water surfaces of the boiler."

While indeed there are certain fuels which show smokeless combustion, such as charcoal, coke, and anthracite, these too demand proper conditions in order that the full thermal efficiency may be obtained from them, so that the whole question of the proper combustion of fuel for steam making can be reduced to certain fundamental principles.

Although these principles have been known for a long time, and their demonstration is included in every elementary course in physics, we see them almost totally ignored in engineering practice. In locomotives we find the combustion carried on in a contracted box in which five of the six walls are formed with water spaces, usually miscalled heating surface, but more properly entitled cooling surface. In the type of marine boiler in general use the fires are maintained in small cylindrical furnaces, than which nothing more effective for chilling the fire could well be devised. Water-tube boilers are nearly always set with the tubes directly over the fire, while the horizontal tubular boiler, so extensively used in the United States, is also set directly above the grate.

The immense influence which these constructions have upon the combustion of the coal will be seen when it is understood that the igniting temperature of bituminous coal is between 700 and 800 degrees F., while the temperature of the water in the boiler, and hence of the metallic surfaces close to the fire, is not more than one-half as much, and therefore complete combustion cannot be expected.

The idea of the practical man is that all this can be remedied by the admission of an excess of air, since he assumes that the presence of oxygen will suffice to make up for lack of temperature. In this he forgets that the finely divided particles of unburned carbon which constitute smoke cannot be so readily disposed of. The particles of carbon are really floating in an atmosphere of nitrogen and of carbonic acid, and in most cases the excess of air admitted never reaches the combustible at all, but serves only to dilute the whole, absorbing heat and passing out of the chimney unused.

The remedy for this state of affairs is obvious, so much so that many overlook it altogether. If the furnace be removed alto-

gether from its close proximity to the cooling surfaces of the boiler, and be surrounded by walls capable of being raised to a temperature higher than the critical igniting point of the fuel, there will be no difficulty in burning all the combustible constituents of the fuel, provided sufficient oxygen be provided. In other words there should be a separate furnace of ample size constructed, conveniently placed in front of the boiler, and containing only the grate, and including walls of firebrick capable of being maintained at a high temperature. The throat of the furnace can communicate directly with the flues or other heating surface of the boiler, and the intensely hot products of the already completed combustion thus delivered where they will do the most good without the possibility of producing smoke.

Again the practical engineer interposes an objection. "We know," says he, "that the surfaces of the boiler exposed to the radiant heat from the fire constitute the most effective portion of the entire heating surface of the boiler; are these to be discarded?" As a matter of fact, we know nothing of the sort. We know that a large portion of the so-called heating surface is far inferior to the rest, but this is due to the fact that it is so placed that it receives only the partially consumed and already cooling portion of the fuel. The fuel contains a definite, and ascertainable number of heat units; when it is fully burned these heat units are released in the sensible form; and, if they do not escape through the walls of the furnace or up the chimney they must be absorbed by the boiler and utilized in the evaporation of water.

Furnaces of this kind are in continual and satisfactory use for the complete combustion of fuels which would be altogether worthless if fed upon the ordinary grate, such fuels as wet spent tan bark, bagasse from sugar mills, etc., and there is no earthly reason why methods entirely practical, and altogether theoretically correct, should not be used for bituminous coal, a fuel quite as unfit to be fed into a common furnace as any which could be named.

It has been said that much of the smoke in British cities comes from the chimneys of private residences, and that properly designed boiler furnaces would abate but a small portion of the evil. There is but one remedy to be offered for this portion of the problem, but it is one which should be promptly accepted. The only fuel fit for household purposes is gas. Fuel gas should be supplied to all houses in cities, and the use of solid fuel become as obsolete as that of flint and steel, tinder, and other ancient nuisances. There is no reason why any great city should be a victim of the smoke nuisance except that of the wilful perversity of its inhabitants, and those who are afflicted by the filth and unhealthfulness of an atmosphere laden with the products of incomplete combustion should receive no sympathy or commiseration from the more intelligent portions of the community.

ELECTRIC DRIVING OF MACHINERY.

LARGE ELECTRIC MOTORS IN THE ANTWERP ROLLING MILLS—GROUP AND INDEPENDENT MACHINE DRIVING IN GERMANY.

La Revue Technique—Glasers Annalen.

ELECTRIC driving of machinery is necessarily on the increase, and present interest is directed mainly towards its methods and its limitations. At first it was supposed that the electric motor was suited only for light machinery, such as small printing presses, laundry machinery, and the like; then, when it appeared that it was well adapted for machine tools of fair size, the question came up as to the economy of using separate motors for small tools, and the arrangement known as "group" driving came into vogue, one motor operating a short section of shafting, from which a number of tools were driven by belting. The driving of such heavy machinery as the rolls of the iron and steel mill, while often discussed, has only recently become a reality.

So far as heavy driving is concerned, the latest example is found in the new iron and steel works under construction at Hoboken, on the banks of the river Scheldt, near Antwerp. Curiously enough, these mills, the

first in which direct electric driving has been employed for heavy rolls, are equipped with machinery sent from America, although such motors have as yet not been employed in this work in Pittsburg, the city of their origin. From an account in *La Revue Technique* we extract some description of these new mills, with especial reference to their power plant.

The works are planned on the most modern lines, there being six blast furnaces of 350 tons capacity each; the daily consumption being 4,200 metric tons of iron ore, 1,070 tons of flux, and 3,050 tons of coal. The coking furnaces, which form a part of the plant, are of the modern by-product type, while an auxiliary cement works is provided for the purpose of utilising the furnace slag.

Electric power is to be used in all departments of the work. The preliminary power plant, operated by steam, includes two 1,500 horse power generating sets; a three-phase current of 2,200 volts at a frequency of 50 cycles being generated. The completed plant is to generate 30,000 horse power, employing gas engines supplied with the waste gases of the blast furnaces, and all the power is to be electrically transmitted from the power house to the various parts of the mills. The most powerful single motors thus far installed are of 350 horse power, these being directly connected to the plate mills and belted to the blooming train. Electric cranes are provided throughout the works, and numerous small motors provide the power for the live rolls, shears, and all the multifarious power machinery of the establishment.

While it is too soon to give operative data concerning this modern installation of electric power, there is every reason to believe that it will be altogether successful, and by reason of its advantageous situation for the receipt of raw material and the shipment of product, it should prove an important commercial enterprise.

The question of the relative advantages of group and independent machine driving for tools of moderate size has been recently given careful study in the shops of the Vienna-Warsaw railway at Pruschkowo, and from an account by Herr von Reichel, in a recent issue of *Glasers Annalen* we give some of the results. The tests were conducted upon a set of four wheel-lathes, which had for some time been operated by independent motors of three horse power each, the supply being a three-phase current of 190 volts pressure. Careful tests, the details of which are given in Herr von Reichel's paper, show that for various speeds and feeds these lathes consumed from 0.88 to 2.40 horse power each.

In order to test the economy of group driving, the same lathes were then belted to a countershaft, which in turn was belted to a single motor, the belting being so arranged that any or all of the machines might be driven. The tabulated results are given in the article, and it appears that the loss of power in the transmission operated to render the group driving decidedly less economical than the use of independent motors for each lathe. This was the more apparent when only a portion of the machines were in operation, and as the general experience is that the full number of machines is rarely if ever in simultaneous operation, this fact must be taken into consideration. Without going into details, it appears that with all four machines in operation the independent system consumed but 69 per cent. of the power required for the group system.

The general conditions under which the machinery is operated naturally affects to some degree the relative economy of the two systems, and hence we give the general conclusions which Herr von Reichel appends to his paper, referring the interested reader to the full account for some very interesting details of an excellently conducted test.

Herr von Reichel finds that independent driving may be considered more advantageous than group driving when not more than 75 per cent. of the machinery is operated continuously during the entire working day; when, however, the operation covers continuously a greater portion of the time, group driving may be found of advantage. In the equipment of new shops and in the planning of new works for electric driving, independent driving should always be used, since the slightly greater first cost will soon be repaid by the greater economy in operation. In the equipment of old shops with electric driving both group and independent driving may be employed

as convenience may indicate, but for machines which are situated at a distance from the motive power, independent driving will be found most advantageous.

It is especially desirable, in equipping a shop for electric driving, to purchase tools especially designed to be operated by electric motors. In case a number of tools in the same place are to be adapted to electric driving much power may be required which might otherwise be saved, had the tools been designed for the application of motors in the first place.

Apart from the direct economy involved in independent driving, it must be remembered that the advantageous placing of the machinery often effects as great a gain in space and operation as is saved in actual energy for driving, and in many instances the latter considerations become of controlling importance, economy of power being secondary.

LIGHT TELEPHONY.

EXPERIMENTS WITH A SELENIUM PHOTOPHONE ON THE WANNSEE, NEAR BERLIN. WIRELESS TELEPHONY WITH A BEAM OF LIGHT.

Ernst Ruhmer in the Elektrotechnische Zeitschrift.

IN the original photophone of Professor Bell, a beam of light was reflected from a diaphragm set in vibration by sound waves, and the undulating beam caused variations in the illumination of a selenium cell placed at a distance. As is well known, the electrical resistance of selenium becomes less with increasing illumination, and if a selenium cell be placed in circuit with a battery and a telephone, variations in the light falling on the selenium will cause variations in its resistance and changes in the current flowing in the circuit, and hence sounds in the telephone.

Modifications and improvements of the original apparatus have been made from time to time, but it has remained little more than a scientific curiosity until recently, when Herr Ernst Ruhmer took up the active development of "light telephony." He has attained a considerable degree of practical success in experiments made on the Wannsee, near Berlin, which he describes in the *Elektrotechnische Zeitschrift*.

Herr Ruhmer's sending apparatus consists of a parabolic searchlight reflector, with a carbon arc light at its focus, a microphone telephone transmitter in circuit with a battery, and an induction coil with one winding in the microphone circuit and the other in the arc lamp circuit. By this arrangement, the rapidly-alternating telephonic currents of the microphone circuit are superposed upon the continuous lighting current, thus causing variations in the intensity of the arc and consequently in the beam of light issuing from the reflector. It is necessary to supply the arc light with current from a primary or a storage battery, for the commutator of a dynamo would cause periodic vibrations in the arc, which would seriously interfere with telephonic transmission.

The parallel beam of light from the reflector, varying periodically with the microphone transmitter current, proceeds in a straight line to the receiving station, where it strikes another parabolic mirror and is reflected to the focus of the latter, at which is placed a selenium cell. The selenium is in circuit with a battery and two telephones, and as its resistance changes with the varying beam of light, the accompanying changes in the battery current produce sounds in the telephone receivers which correspond with the sounds uttered into the transmitting telephone at the sending station.

As Herr Ruhmer remarks, good transmission of speech by this method depends on the amplitude of the microphone current oscillations, on their proper superposition upon the continuous current of the lamp, on the strength of the lighting current, on the accuracy of the parabolic reflector and its proper mounting, on the clearness of the atmosphere, on the size of the receiving mirror, on the sensitiveness of the selenium cell, and finally, on the proper voltage of the battery and resistance of the telephones at the receiving station.

Perhaps the most essential feature of the whole system is the selenium cell. It is necessary that it should be sensitive not only to light in general, but particularly to

those wave lengths whose amplitude is most widely varied by the transmitting apparatus. Now it has been found that it is the short light waves which are chiefly concerned in producing the "speaking" beam, and on the other hand, ordinary selenium responds most readily to those rays which are comprised between the red and the greenish-yellow parts of the spectrum. Herr Ruhmer has succeeded, however, in constructing selenium cells which are sensitive to all wave lengths of light, and which, moreover, when the illumination ceases, return to their original state with remarkable rapidity. His selenium cells are made with thin layers and are cylindrical in form, so that when placed at the focus of a parabolic mirror, they will be illuminated on all sides. The sensitive cylindrical surface is 23 millimeters long and 18 millimeters in diameter. When in the dark the resistance of such a cell is 120,000 ohms. With an illumination of 64 lux, the resistance falls to 9,100, and at about 20,000 lux,—corresponding to the illumination due to a sixteen-candle incandescent lamp close by, or that of the winter sun on a surface perpendicular to its rays—the resistance is only 1,500 ohms.

In the experiments conducted on the Wannsee, the transmitting apparatus was carried on an electric launch, equipped with an accumulator battery, and the receiving station was placed at different points on the shore, or on another boat. Successful transmission was attained at distances ranging up to 7 kilometers, in all kinds of weather from clear to rainy, and by day as well as by night. It is rather surprising to learn that operations succeeded in daylight, but it was found that when the receiving mirror was shielded from the direct rays of the sun, very good transmission was secured.

These results are an advance on anything of the kind that has been done before, and are highly gratifying, but their practical importance is somewhat diminished by the rapid progress of wireless telegraphy, whose range is so greatly in excess of that of the photophone, and which will most probably be adapted to the practical transmission of articulate speech before very long.

Light telephony can never work over greater distances than can a heliograph, and is subject to the other limitations of the latter, but within these limits it may well find a field of usefulness, particularly in military operations.

AN INTERESTING ANNIVERSARY PUBLICATION.

PAPERS BY THURSTON, MELVILLE, SWEET, BOOTH, AND OTHERS UPON THF ENGINEERING DEVELOPMENT OF A QUARTER CENTURY.

American Machinist—Twenty-fifth Anniversary.

OUR interesting contemporary, the *American Machinist*, having reached its twenty-fifth birthday, very properly celebrates that event by the issue of an anniversary number, and in it appears a number of articles by men who have been identified with the growth of mechanical engineering during that period. The limitations of space will not permit more than a passing glance at some of these contributions, but some quotations may serve to show how the development of the period looks to men who have not only seen it, but have in great measure been instrumental in bringing its changes to pass.

Thus, speaking of the progress of technical education, Professor Thurston says: "The literature of the mechanical and engineering departments of industry has come to be extensive and is constantly growing in quantity and quality at an accelerated rate. Its character has greatly changed and the most important problems of the mechanic, the constructor and the engineer are now capable of scientific and exact solution, and the sporadic production of improved devices and of "inventions" by the amateur genius is largely superseded by the deliberate and exact study of the problem of improvement by the designer, by his precise definition of the conditions to be met and by his scientific and accurate solution of his problems. The art of exact design, based upon scientific principles and experimentally determined, accurate data, is the modern expert's method of supersedure of the older ways of the amateur inventor."

Rear-Admiral Melville, among other in-

teresting points which he makes concerning the work of the engineer in naval affairs, shows the close connection between industrial and military supremacy.

"The comparative strength of nations as regards sea power, as well as their relative position in dominating the affairs of the world, is directly proportionate to the output of their industrial establishments, since the relative measure of naval strength of different countries can better be determined by the number and character of the naval stations and ship-yards which they possess than by the vessels which are in the several navy lists. The engineer, whether afloat or ashore, has thus become a military as well as an industrial factor, and it will be the outcome of his work which will decide the battles of the future, whether fought on land or sea.

"Another important effect of the work of the engineer in military and naval development rests in the fact that all nations have been taught that in the future the art of war will be more dependent upon the principles of engineering than of military tactics. The strategy of the future will involve a knowledge of the possibilities of mechanical appliances, for hereafter the weather gage of the enemy will not be secured by the smart seaman, but by the skilful engineer. The movement of armies on land will not be dependent upon some stroke of military genius, but rather upon the reflective work of some engineer who has mastered the subject of transporting safely and expeditiously large bodies of men and supplies."

The mooted question of British and American machine tools is treated by Mr. W. H. Booth in by far the most sensible manner we have seen for a long time. Speaking of the fact that American tools, when transplanted to England, failed to give the output of work which they had shown in the land of their origin, he calls attention to the fact that the discrepancy might be due to other causes than the antagonism of the workmen. A portion of the difference at least, he considers to be due to the harder material used in Great Britain.

"American tools coming over here have become heavier, and when heavier tools began to come over we began to hear complaints that they would not do the work they were sold to do and they were worn out of truth in a few months. This rapid wear was urged as a reason for scrapping, but it is certain that ordinary machine tools are not so obsolete in a year's time as to require scrapping. The obsolete theory was somewhat overdone.

"I have gone carefully into this question of the hardness of cast iron, and, personally, I have no shadow of doubt that English cast iron is very much harder than anything that comes from outside. The wear that takes place in American tools manifests itself in two ways: First, it compares with the wear on our own hard irons; and, secondly, American tools made to cut American iron were too light and had surfaces too small when set to cut our hard iron. Then the attempt to run the tools at the speeds stated they would run was provocative of disaster. Failure was laid to British clumsiness on one side and to Yankee flimsiness on the other. Sober-minded men realized that the whole matter was one of materials."

There is no doubt that tools of American design, made on either side of the Atlantic, have become modified by the nature of the work which they have to do; and the result is the production of what was predicted in these columns several years ago, the international design of machine tools, in which the good points of the practice of all industrial nations are being combined, and the weak features of all eliminated.

Professor Sweet invariably gives food for thought in his utterances upon practical questions, and in his review and glance forward he gives a glimpse of improvements which may be expected in the machine designs of the near future.

"If the machine tool builder of to-day could fully grasp the revolution that is to come over the trade within the next quarter of a century it would be a revelation to him, and yet a glimmer of what it is to be can be dimly seen. While all the standard machines will still be made and used, they will be built primarily to do work rather than to suit the convenience of the operator, and so improved that they will still be easier for the operator to handle. Instead of the designers studying to find out where they can take out a pound of iron and not have the machine weakened, they will study to find

where they can put in another hundred and make it pay in the more and better work the machine will do. They will revolutionize the drive and feed mechanisms so that the workmen can get the best of both without exertion, and they must to a large extent make the machines self-contained and true, wherever they may be set and on whatever they set, for many of the machines are to go to the work and not the work to the machines."

"Great industries permit of great quantities. Special machines will be more largely employed, because then there will be pieces enough of one kind to keep one or more machines employed at a few operations or a single one, and there will be far less idle capital in long machines doing short work and large ones doing small work. When there is enough of a kind the automatic machine will do the work, and inconsistent demands from inconsiderate workmen may in many cases develop automatic machines before even economy justifies their existence."

The entire number is a most interesting review of the work of the individual from whom our valued contemporary takes its name, a record of the work of the machinist in the United States of America.

THE ECONOMY OF LARGE SHIPS.

CAUSES FOR THE INCREASING TENDENCY FOR THE CONSTRUCTION OF VESSELS OF GREAT CARRYING CAPACITY.

A. W. Robinson—Canadian Society of Civil Engineers.

THE marked tendency towards increase in size and carrying capacity of ocean steamers is a fact so generally recognized that it needs no comment as such. The causes for this increase, and its influence upon river and harbor work form the subjects of a paper presented before the Canadian Society of Civil Engineers by Mr. A. W. Robinson, from which we make some abstracts.

As to the causes of the development, the facts are not difficult to discover. They are not greatly different from those which have operated to produce similar growth in the capacity of apparatus for transport in all lines of work. In railroad practice the development in the size of cars is well known, and it is a fact that in the past ten years the paying load hauled by a locomotive has been about doubled. This advance has been due to the increase in the carrying capacity of the cars and the hauling power of the locomotives, as well as to the improvement in the roads by reason of the reduction of grades and curves. Railroad men well understand that the cost of transport to them is measured by the train mile, while their charges to the customer are made by the ton mile, so that the commercial reason for the effort to increase the tonnage of the train mile is readily seen.

Much of the great improvement which has been made in the output of manufacturing establishments is due to the introduction of convenient and capacious transport facilities, while in the work of the civil engineer nearly all the appliances which he uses in handling materials have greatly increased in capacity during the past few years.

"In ocean steamships a different state of conditions is found, and as no improvement can be effected in the natural highway of the sea, we must depend entirely upon the development of marine engineering in obtaining higher efficiency in engines and boilers, and in larger carrying capacity of the vessels themselves. It has been found that the propelling power required for a vessel for a given speed increases in a slower ratio than the increase of its displacement, and in this fact is found the main secret of the superior economy of large vessels. A good deal has been done during the past ten years in the improvement of engines and boilers of ships, and in the reduction of weight and space occupied by them, but this improvement is small compared with the increased economy produced by increasing the size alone. During the past ten years the paying load carried by a representative ocean cargo steamer has about doubled, while the average increase in fuel economy has been reduced from 1.52 pounds coal per horse-power per hour to 1.48 pounds—a comparatively small saving."

Constructively, the limitations as to size in shipbuilding have by no means been attained. The "Celtic" is about 700 feet long, 75 feet beam, and 33 feet draught; with a displacement of 33,500 tons, and a gross tonnage of 20,800 tons, and this is about the present limit, not of shipyards and marine engineering, but of harbor draught and port facilities. This fact is realized, partially, at least, and harbors all over the world are being dredged and docks and channels extensively improved to enable larger vessels to enter.

"It is an unnecessary truism to say that large ships will not be economical unless they can be filled, but this aspect of the question merits more than passing notice. The difficulty of providing cargo for these large vessels is very great, and their advantages will not be realized unless there is a corresponding growth all along the line in facilities for receiving, warehousing, and rapid handling of the different kinds of freight in large quantities.

"In the keenness of competition of the present day it is the large economic cargo carrier which will aid the most in the development of ocean trade, and ships of very great speed are only required for the purpose of carrying mails, and for carrying the comparatively small number of passengers who are willing to pay the extra price for the saving of time.

The subject of fast ships is always an interesting one to engineers, as it calls for the highest skill in design and construction, and the problem is no easy one.

It is a great testimony to British shipbuilders that they have been and are still able to produce ships as fast as any in the world, although the Germans have the honours at present with the "Kronprinz Wilhelm," at 23.08 knots, and propose to beat it with the "Kaiser Wilhelm II." now building. It is satisfactory to see that the Cunard Company now propose to build two boats at about 25 knots, under a subsidy arrangement with the British Government, and so the race for supremacy in speed goes on. This is a testimony that British builders stand ready to produce any vessel that the companies are ready to pay for and that great speed is as much a commercial question as an engineering one.

The price of speed is so great that it precludes carrying freight economically or carrying freight at all, and the present tendency of British practice for general freight and passenger service is towards a type of vessel which combines moderate speed with large carrying capacity. It will be interesting to compare the speed and carrying capacity of the two largest ships in the world now building, the "Cedric" and the "Kaiser Wilhelm II."—the "Cedric" representing a type of vessel having large capacity combined with moderate speed, and the "Kaiser William II." representing a type in which everything is sacrificed to speed.

A COMPARISON OF THE TWO GREATEST VESSELS NOW BUILDING.

	Displacement.	I. H. P.	Speed Knots.	Dead Weight.	Pass. Accom.	Tons Coal Per Day.
"Cedric"	37,800	14,000	17	18,000	3,000	260
"Kaiser William II."...	26,000	40,000	24	none.	1,800	750

It is apparent from the foregoing figures that the extra seven knots speed is obtained at the cost of an additional coal consumption of nearly 500 tons of coal per day, and that the passenger accommodation is much less and the cargo capacity entirely lost. This will give some idea of the enormous cost of high speed."

Mr. Robinson applies the facts thus set forth to the case of the navigation of the St. Lawrence river, but they may be equally used in connection with other harbors and navigable streams. The fact may as well be realized now as later that those ports which expect to retain their commerce must provide same channels of ample depth and proper harbor handling and warehousing facilities for the large steamers. Vessels of 1,000 feet in length and 40 feet or more draught will have to be reckoned with before very long and only those seaports which have prepared themselves for such visitors will be able to reap the advantages of the commerce which such ships will bring.

ELECTRICALLY-OPERATED TRANSPORT APPLIANCES.

THE INFLUENCE OF ELECTRIC POWER UPON THE DEVELOPMENT OF CRANES, HOISTS, AND GENERAL CONVEYING MACHINERY.

Verein Deutscher Ingenieure.

AMONG the industrial applications of electric power and transmission, one of the first to be made was that of use for operating hoisting and conveying machinery, probably because of the readiness with which the current could be transmitted from a stationary to a moving body. The whole question of the influence of this application of electricity upon the design of machinery for handling materials forms the subject of an important paper presented by Herr Kammerer at the Düsseldorf meeting of the *Verein deutscher Ingenieure*, and published in succeeding issues of the *Zeitschrift* of the Society.

Herr Kammerer first reviews the construction and capacity of hoisting and handling machinery before the applications of electric power, showing how the usual power transmitting system for indoor work was that of the flying rope, while for docks, warehouses, and outdoor service, hydraulic transmission, with all its inconveniences, was in general use. The relation which these systems of power transmission bore to electric power is shown by curves, giving excellent comparative ideas of the relative efficiency of the different methods.

By far the most important advantage of electric power for hoisting and conveying, however, lies in the ease with which the current may be delivered to any moving portion of the machinery from any other part. With this is united the advantage that a motor can be placed upon the very part which is to be operated, thus reducing the elements of the transmitting machinery to a minimum. The fact that the speed of the motor may be regulated at will within all reasonable limits also adds greatly to its availability for this particular service.

Prior to the application of electric driving to the travelling crane, for example, the varied operations of bridge travel, trolley travel, and hoisting, with all their necessary variations in speed and direction, had to be derived from one source of power, delivered to the travelling bridge through the medium of a flying rope, square shaft, or similar inconvenient device. The result was that the complete travelling crane of a decade ago was rightly called one of the most highly organized machines in use, carrying as it did, a mass of gear wheels, shafts, clutches, reversing mechanism, etc., etc., all these complications being increased because of the necessity for transmitting them to the parts moving over the whole space included in a system of rectangular coordinates, commonly expressed by the three terms, bridge travel, trolley travel, and hoist.

The earliest application of electricity to this problem was but a partial solution. The flying rope or square shaft was replaced by an electric contact, and power was thus conveniently delivered to the travelling bridge. Here, however, it was used to operate a single motor, which in turn drove all the same complicated mass of machinery which had formerly been found necessary, and which it was difficult to conceive could be entirely thrown away. The success which attended this imperfect treatment of the subject, however, led almost immediately to the complete realization of the possibilities of the new system, and now all such cranes are made with separate electric motors for each function, thus sweeping away at one stroke the entire collection of transmitting machinery formerly necessary. There is no such example elsewhere to be found which so completely demonstrates the mechanical superiority of electricity for the transmission and subdivision of power and motion.

Apart from the applications to cranes, we have the newer uses permitting designs of machinery for handling materials which could be accomplished only imperfectly with the older means for power transmission. Thus, the various telpherage systems, in which carriages are operated over spans of cable or other supporting structure, are a great improvement over the earlier types of conveyors in which the entire cable was obliged to be kept in motion. The same improvement is seen in the small trolley

hoists for use in machine works and warehouses, in which the hoist is suspended from the flanges of an overhead system of beams. These were formerly always operated by hand, and their capacity and speed were correspondingly limited, but now it is possible to equip them with small motors and reserve the human element to the control and application of the power so conveniently made available by electricity.

Herr Kammerer gives illustrations of a great number of applications of electric power to hoisting and handling machinery, showing the great influence which the change has made upon the design and use of such machinery, and the paper forms a most interesting contribution to the development of machine design.

THE PERSONNEL QUESTION IN THE UNITED STATES NAVY.

WHY THE PLAN FOR MODERNIZING THE AMERICAN NAVAL SERVICE HAS NOT BEEN FAITHFULLY CARRIED OUT.

Report of Rear Admiral Melville.

So much has already been said in these columns concerning the failure of the Navy Department of the United States to carry out the clear meaning of the Personnel Bill that it seems as if there was little more which could be added to penetrate the consciousness of those to whom the administration of the laws has been entrusted; but the closing portions of the report of the Engineer-in-Chief show that the matter is not yet settled. This is the more surprising from the fact that the President of the United States, when Assistant Secretary of the Navy, uttered the comprehensive words:

"Every officer on a modern war vessel in reality has to be an engineer, whether he wants to or not. Everything on such a vessel goes by machinery, and every officer, whether dealing with the turrets or the engine room, has to do an engineer's work. There is no longer any reason for having a separate body of engineers, responsible for only a part of the machinery. What we need is one homogeneous body, all of whose members are trained for the efficient performance of the duties of the modern line officer. The midshipman will be grounded in all these duties at Annapolis, and will be perfected likewise in all of them by actual work after graduation. We are not making a revolution; we are merely recognizing and giving shape to an evolution which has come slowly but surely and naturally, and we propose to reorganize the navy along the lines indicated by the course of the evolution itself."

Admiral Melville calls attention to the fact that the bill was criticised at the time of its passage because it did not make explicit provision for compelling the enforcement of engineering duty. President Roosevelt had no such scruples, but, as above quoted, recognized the fact that officers would not want to become engineers.

It was maintained that departmental orders and regulations would be promulgated to enable the spirit of the bill to be carried out, but experience has shown that nothing short of a club will induce a line officer to become an engineer. To quote again the words of President Roosevelt: "He has to be an engineer, whether he wants to or not."

That this state of affairs is not creditable to the navy of the United States must be admitted, but apparently it cannot be helped. These men doggedly oppose the clear intent of the personnel bill, and hiding behind the omission of any provision for the enforcement of the bill, continue to decline to stand engine-room watch, or to fit themselves for the responsibilities for which they are drawing pay.

At the present time the bulk of the engineering work in the navy is being performed by warrant machinists. That this can make up for the delinquencies of the officers, Admiral Melville does not believe. Says he:

"While the warrant machinists have had shop training and experience at sea, it can not be expected that they possess the necessary scientific training to enable them to take up the most important duties that were performed in the past by the commissioned officers of the old Engineer Corps. These men may have the skill to adjust bearings,

set a valve, replace a water tube in a modern marine boiler, overhaul a pump, and possess the requisite knowledge for operating machinery with which they are familiar, but in matters of organization the services of more highly trained men are needed. There are great laws of mechanics, physics, chemistry, and thermodynamics which must be put to practical application by the chief engineer of a war ship. It is a thorough grasp of these principles, combined with practical sea experience and power of observation and study, which makes the competent marine engineer.

"It is not my desire to disparage the work of the warrant machinists. These men are rendering useful and efficient service, and provision should be made whereby the elect might quickly secure commissions in the Navy. It is my great desire to encourage them and advance their material interests, but as a rule this class of officers can no more do the work of trained and educated engineers than can carpenters take up the duty of naval constructors, gunners assume the responsibility devolving upon ordnance experts, or boatswains attain the skill and executive ability of skilled sea commanders."

Although the enactment of the personnel bill was received with adverse criticism from naval officers of various countries, Admiral Melville does not share in the belief that it was a mistake. On the contrary he says:

"The principle of amalgamating the duties of the line and engineer officers is in accord with the trend of modern development, and it is by reason of this fact that the proposition received the hearty and unqualified support of the engineering interests throughout the country. It was an official recognition on the part of Congress, of the dignity and importance of the engineering profession. It was also an emphatic declaration on the part of the legislative assembly that an organization which was suitable for vessels of oak was not compatible for the needs of ships of steel, and that the men beneath the protective deck in the engine rooms and stokeholds were as much an integral part of the ship as the men who served and trained the guns. This legislation, however, assailed the traditions of the service, and it was not surprising that opposition developed when it was presumed that vested rights had been encroached upon. This opposition was powerless in its appeal to Congress to reject the measure. It commanded greater strength within the naval service, and it is this influence which stands in the way of a liberal and generous enforcement of the unwritten, but well understood provisions of the personnel law."

"If the law is administered with a desire to make it a success, it will beyond a doubt give us the most efficient navy in the world. It must, however, be administered in a way that will prevent junior officers from showing a decided preference for deck duty, and this result can in great part be secured by refusing to promote those who have not had actual and continuous experience in the engine room, and whose semi-annual reports as to fitness do not show that they have been zealous and proficient in the performance of engineering duty."

No additional legislation is needed for the proper execution of the personnel law. It is only necessary that the President, under whose personal auspices as assistant Secretary of the Navy the bill was prepared, shall appoint a Secretary of the Navy who realizes that it is his plain duty to make every officer in the navy an engineer, "whether he wants to be or not."

POSSIBILITIES IN LOCOMOTIVE DESIGN.

A COMPARISON IN DEVELOPMENT OF AMERICAN AND EUROPEAN TYPES AND THEIR MUTUAL INFLUENCE UPON FUTURE ENGINES.

An Address by Professor W. F. M. Goss.

THE difference in appearance which every traveller notices in the locomotive engines of various countries is a matter which has often received comment, and while the engineer knows that these differences are mainly in detail, and not in general principle, it has generally been thought that each type was the outgrowth of the necessities of its peculiar locality. While this is true to a limited extent it is

much less so than many imagine, and there is little doubt that the locomotive of the future, at least until steam is displaced by electricity, will tend more and more toward an international type, combining the experience of many places and men.

So far as the American locomotive is concerned, the conditions which led to its present form are clearly set forth in an interesting address delivered by Professor W. F. M. Goss at the Deer Park convention of Baltimore & Ohio officers, and published in a recent issue of the *Railroad Gazette.*

Passing the early experimental period, the American locomotive took the fundamental elements of its present form during the great period of activity between 1850 and 1860, when the railway mileage of the country increased from 8,000 miles to 29,000 miles, or nearly 260 per cent., much of this growth being in new and partially developed parts of the land.

"The effect of this expansion upon the design of locomotives was great. As these thousands of miles of road extended themselves over the country, their equipment became necessary. Locomotives were in demand. These could not often be supplied by the railroad companies themselves, for their energies were being expended in extending lines, and, in most cases, they were without facilities for producing them. In these early days the officials of the roads had little time in which to give either thought or suggestion concerning the details of equipment, and the builders of locomotives, with an abundance of orders in hand, and with no highly-organized staff of designers to study the needs of individual roads, followed naturally the lines of least resistance. It was to have been expected under these conditions that each builder would supply all customers with engines of the same general type, and it was equally natural that each should seek to strengthen his own practice by the experience of his neighbors. In this manner, each contributing something to the solution of the common problem, there gradually came into existence a distinct and generally-adopted design, the American-type locomotive, a development by experimental processes, from very early beginnings."

The growth of railroad construction in the United States continued from 1860 to 1890 without material change, the enormous demand for locomotives continuing as the construction mileage of the country grew, until at the close of the eighties the railways of the United States reached the total of more than 163,000 miles. Such a demand called for properties which the American locomotive met very effectively. Fuel economy was a minor consideration. The engines were constructed to meet other requirements.

"With their 16 in. or 17 in. cylinders and 120 or 140 lbs. of steam, they carried good loads and ran at fair speeds. They responded perfectly to the demands of a mixed service, sometimes doing switching, sometimes pulling a freight, and sometimes a passenger train. They were sufficiently flexible to be but little affected by roughness of track, and their parts, being few and strong, were not often deranged or broken. The efficiency of these engines, both as to boiler performance and cylinder action, is probably not exceeded by that of the modern simple locomotive. When to these obvious advantages, there is added a low first cost and a low cost of repairs, the preference which has been accorded the American type is readily explained."

About a dozen years ago the conditions changed, and with the cessation in railroad building and the diminution in demand for engines the business declined, and upon its revival it was found that new conditions had to be met. There is now a demand for higher efficiency in the operation of trains, and locomotives are more generally required to be designed for specific services.

The great claim for the older type of American locomotive was its simplicity, and many valuable improvements were condemned on the ground of their complication. Fear of complication has to a great extent passed away, and very naturally, too, in view of the increasing complication of all departments of work and life. As Professor Ayrton well said, upon another occasion, the graduated candle of King Alfred was infinitely simpler than the modern watch, but no one thinks of discarding his watch to-day on that account.

Leaving aside, then, the limitations set by the older designers, Professor Goss proceeds to examine the lines along which loco-

motive improvement may be expected. First among these he places the handling of the fuel. It cannot be accepted that the development of the locomotive can be retarded by the fact that its power is to be measured by the physical ability of one man to feed its furnace. There are several alternatives, among which may be mentioned oil fuel, powdered coal, and mechanical stokers; certainly however this may be, there is little doubt that the capacity of some existing engines could be increased 10 to 20 per cent. if they could be adequately fired.

Steam economy, until now a secondary consideration, has come to the front, not so much for the purpose of saving coal as for the necessity of increasing the ratio of boiler to engine power. This leads at once to the consideration of compounding.

"As a general proposition, compound cylinders require less steam than simple cylinders for the development of a given amount of power. A saving in steam implies a reduction in the quantity of water to be handled, and hence, compounding should prove advantageous in localities where water is scarce or bad. A saving in steam also implies a reduction in the amount of coal required to perform a given service, and, hence, compounding should be popular wherever fuel is expensive. A saving in the amount of steam used per horse-power per hour permits the development of greater cylinder power in connection with a boiler of given dimensions and weight, so that compounding becomes a means by which the limit of power may be raised when the weight of the locomotive as a whole has been fixed."

Since this question of compounding has reached a further development in Europe than in America, it is here that the influence of European locomotive design upon American construction must be expected to show the greatest influence. Including the question of balancing, there is every reason to believe that the four-cylinder compound type of M. de Glehn, extensively used on the Continent, presents many advantages. The early American prejudice against cranked axles may well be abandoned, in view of the better material and construction now existing, as well as the improved condition of American road-beds, permitting sufficiently smooth running to insure against axle breakages.

Professor Goss makes an excellent argument to show that the simplest machine is not always that which has the fewest parts. Upon this important question we may be permitted to quote his own words only emphasising the strength of his position by affirming our full agreement with his conconclusions.

"An excellent example of this is had in the case of certain marine engines. Both in merchant and naval service, four-cylinder triple-expansion engines are now not uncommon. It is true that three cylinders would be sufficient to satisfy the thermodynamic conditions involved, but if only three cylinders are used, the volume required for the last expansion necessitates the use of a low-pressure cylinder of dimensions too great to be conveniently handled or operated. Under such conditions, two low-pressure cylinders, each having half the required volume, are employed, and, so far as I know, no one has ever attempted to argue that the addition of parts thus involved in any way increases the chances of derangement or delay. On the other hand, the whole effect of the sub-division is to give increased security against such delay. Is not the time at hand when improvement in this line will be made by a sub-division of some of the larger parts of the American locomotive? Believing such a change imminent, I have hopes that in securing the advantages of such a sub-division, the opportunity which presents itself, both for compounding and for perfect balancing, will not be allowed to pass unimproved.

"I look forward, then, to the representative American locomotive of the future, as an engine capable of exerting even greater power than the modern engine. I predict that it will be automatically supplied with fuel; its thermodynamic performance will be made high through the adoption of compound cylinders, and its mechanical action perfect, through the balancing of its reciprocating parts. With such a locomotive and with a track which is in keeping with the improved action of the locomotive which is to run upon it, the present generation will not need to blush when called upon to give over its responsibilities to that which is to follow."

THE ENGINEERING INDEX

THE ENGINEERING INDEX IS THE KEYSTONE OF APPLIED SCIENCE"

The following pages from a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world,—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

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The Competition for a Second Fixed Bridge over the Rhine at Cologne (Der Entwurf zu einer Zweilen Festen Rheinbrücke in Köhn). M. Foerstner. With illustrations of the proposed suspension truss bridge of 220 metres clear span. 1800 w. Schweizerische Bauzeitung—Sept. 27, 1902. No. 51336 B.

Collapse.

Collapse of a 200-foot Highway Bridge Over the Colorado River at Gonzales, Tex. Brief illustrated account of an accident caused by the failure of one of the double-cylinder piers on which is was carried. 800 w. Eng News—Oct. 9, 1902. No. 51093.

Concrete Arch.

Warped Ends for Concrete Arch Culverts. Daniel B. Luten. Illustrates and describes four structures built under the writer's supervision in which wings and parapets were omitted, the arched ring being finished in the warped-end style, giving reasons for the adoption. 1700 w. R R Gaz—Oct. 3, 1902. No. 50934.

Construction.

Bridge and Building Construction on the Louisville & Nashville R. R. General

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plans of some of the structures with account of progress. Ill. 7000 w. Ry & Engng Rev—Oct. 18, 1902. No. 51211.

Costa Rica.

The Rio Grande Bridge of the Pacific Railway of Costa Rica. An illustrated description of the construction and erection of this bridge on the Pacific Railway of Costa Rica, with information concerning the country, the engineering difficulties, etc. 4400 w. Eng Rec—Oct. 25, 1902. Serial. 1st part. No. 51240.

Danube.

King Charles I. Bridge Across the Danube. Nicolae Ionescu. An account of the circumstances which led to the building of the bridge, the conditions to be met, and an illustrated description of the structures. 1000 w. Sci Am—Oct. 25, 1902. No. 51290.

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Highway Bridge of 465-Ft. Span Over the Miami River, at New Baltimore, Ohio. Elevation and plan with description of one of the longest highway bridge spans in the United States. 700 w. Eng News—Oct. 16, 1902. No. 51218.

Philadelphia.

The Pennsylvania R. R. Bridge at Fifty-second Street, Philadelphia. Illustrates details and describes a bridge built to avoid a grade crossing. It includes two long viaduct approaches and a single through span, weighing about 900 tons. 2200 w. Eng Rec—Oct. 25, 1902. No. 51242.

Reconstruction.

Reconstruction of a Railway Bridge Near Mayence. An illustrated account of the various stages of the work. Each of the old 115 ft. flood spans was, in a space of two hours, replaced by a new one weighing nearly 80 tons. 900 w. Engr, Lond—Oct. 10, 1902. No. 51176 A.

Thames.

New Kew Bridge. The present article deals with the removal of old foundations, describing the construction work, and giving illustrated description of construction details of the new bridge. 1800 w. Engr, Lond—Sept. 26, 1902. Serial. 1st part. No. 50967 A.

Viaduct.

Launching the Metallic Superstructure of the Viaduct over the Rhone at Avignon (Lançage de la Superstructure Métallique du Viaduc sur le Rhône à Avignon). Describing the erection of this important railway bridge. There are six spans of 73 metres each and two of 58 metres. 2000 w. 1 plate. Rev Gen des Chem de Fer—Oct., 1902. No. 51379 H.

CANALS, RIVERS AND HARBORS.

Barge Canal.

The Ontario Route for a Barge Canal vs. the Seneca-Oneida-Mohawk Route. T. W. Symons. An argument against the Ontario route and in favor of the inland route, with editorial discussion. 4800 w. Eng News—Oct. 2, 1902. No. 50926.

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Projected Breakwater at Alicante (El Dique de Abrigo Proyectado de Alicante). José Nicolau. A general review of the existing conditions of navigation and the proposed improvements at the port of Alicante, Spain. 2500 w. 2 plates. Revista de Obras Publicas—Sept. 4, 1902. No. 51351 D.

Dredging.

A New Clam Shell Dredge Operated by Compressed Air. Illustrates and describes a recent invention of E. Chaquette for closing and opening a clam shell for subaqueous excavation. 1100 w. Compressed Air—Oct., 1902. No. 51233.

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Scheveningen.

The Harbor of Scheveningen (De Binnenhaven te Scheveningen). P. J. Van Voorst. Data concerning the dredging of the harbor, breakwater construction and general improvements. 7000 w. De Ingenieur—Sept. 27, 1902. No. 51367 D.

Streams.

Limiting Width of Meander Belts. Prof. Mark S. W. Jefferson. A study, seeking to establish a limit for the width of the belt of meanders of any given stream. Ill. 3300 w. Nat Geog Mag—Oct., 1902. No. 51029 C.

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The Philadelphia Company's Building, Pittsburg. Illustrated description of the foundation and steel-work of a high office building. 3500 w. Eng Rec—Oct. 4, 1902. No. 50946.

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Dam.

A Concrete Power Dam at Middle Falls, N. Y. Illustrated description of a dam having long spillways at each side at right angles to its axis. 1200 w. Eng Rec—Oct. 4, 1902. No. 50944.

Masonry.

The Cause of Masonry Disintegration. Halbert Powers Gillette. Arguing that masonry destruction in cold climates is due primarily to stresses developed by expansion and contraction due to changes in temperature. 2800 w. Eng News—Oct. 23, 1902. No. 51285.

Military Engineering.

The Engineer in the Moro Campaign. An account of the extent to which engineering work has participated in the campaign of the American troops against the Moros in the Philippines. 2000 w. Engineering Magazine—November, 1902. No. 51398 B.

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Modern Pile Drivers. Waldon Fawcett. Considers some of the characteristics of modern pile-driving machinery, and the severe requirements to be met. Ill. 1000 w. Sci Am—Oct. 4, 1902. No. 50935.

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A Study of Road-Building Gravels. Ira O. Baker. Discusses the requisites for a good road gravel, and gives results of a study of a number of well-known gravels. 3500 w. Eng News—Oct. 23, 1902. No. 51286.

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sistance of Reinforced Concrete to Compression (Etude Experimentale de la Resistance á la Compression du Beton Fretté). M. Considère. An account of experiments made to show the relation between the computed and actual crushing strength of hooped prisms. 1800 w. Comptes Rendus—Sept. 8, 1902. No. 51375 D.

Structures in Armed Cement (Il Cemento Armato). A description of the construction of culverts and viaducts in reinforced concrete on the line of the Southern Railway of Italy. 2500 w. Il Monitore Tecnico—Oct. 10, 1902. No. 51370 D.

The Resistance of Reinforced Concrete to Tension (Résistance à la Traction du Béton Armé). M. Considère. A discussion of the tests made by the Department of Public Works, showing the influence of the metallic reinforcement upon the elasticity. 1500 w. Comptes Rendus—Aug. 18, 1902. No. 51373 D.

The Resistance of Reinforced Concrete to Compression (Etude Theorique de la Résistance à la Compression du Béton Frette). M. Considère. A study of the increase produced in pillars of concrete by surrounding them with metallic hoops. 1800 w. Comptes Rendus—Aug. 25, 1902. No. 51374 D.

Sand and Gravel.

A Study of Hard-Packed Sand and Gravel. W. O. Crosby. Describes material encountered in the modified drift of the Nashua Valley, south of Clinton, Mass., and a series of tests made. 1400 w. Tech Qr—Sept., 1902. No. 51126 E.

Sand-Binder.

Marram Grass as a Sand-Binder, in Victoria-Australia. A report of the writer's experience and the method adopted. 800 w. Eng News—Oct. 23, 1902. No. 51281.

Structural Steel.

The adoption of a single Grade of Steel in Structural Specifications. Albert J. Hines. Arguments favoring the adoption for all ordinary requirements, but allowing the making of special steels for unusual requirements. 1400 w. Eng News—Oct. 23, 1902. No. 51282.

Uralite.

The Manufacture of the New Fireproof Material Uralite. Illustrates and describes this new material which originated in Russia and takes its name from the Ural Mts., giving the process of manufacture, the notable features, tests, etc. 2000 w. Sci Am—Oct. 4, 1902. No. 50938.

Uralite: New Fireproof Material. A description of this material, its various advantages and uses. 2000 w. U S Cons Repts. No. 1463—Oct. 7, 1902. No. 50942 D.

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Slide Rule.

The United States Geological Survey Topographic Slide Rule. Gerald H. Matthes. Illustrated description of this slide rule, designed by the writer, with an outline of problems demonstrating its use. 3300 w. Tech Qr—Sept., 1902. No. 51125 E.

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The Brookline Baths. Waldon Fawcett. A description of these public baths, the first municipal bath of its kind in the United States, with information relating to their use, cost, etc. 2000 w. Munic Engng—Oct., 1902. No. 50871 C.

Pavements.

The Development of the Bituminous Macadam Pavement. Fred J. Warren. Abstract of a paper presented to the Am. Soc. of Munic. Imp. Describes a pavement combining the essential principles of both asphalt and macadam, giving the theories on which the construction is based. 2300 w. Eng Rec—Oct. 11, 1902. No. 51116.

The Maintenance of Asphalt Streets. Discussion of paper by James N. Hazlehurst. 8500 w. Pro Am Soc of Civ Engrs—Oct., 1902. No. 51254 E.

The Use of Wood Pavements Under Heavy Traffic. F. A. Kummer. Abstract of a paper presented to the Am. Soc. of Munic. Imp., showing that wood blocks laid with a tight joint, with selected wood and latest practice of construction, show a fine record as to wear. 1500 w. Eng Rec—Oct. 18, 1902. No. 51221.

Refuse Disposal.

Refuse Destructors. W. Francis Goodrich. A review of progress with discussion of systems, apparatus, costs, etc. 3300 w. Mech Engr—Oct. 18, 1902. Serial. 1st part. No. 51409 A.

Sanitation.

Report of the Chairman of the Committee on Sewerage and Sanitation. Prof. A. Prescott Folwell. Presented to the Am. Soc. of Munic Imp. Considers municipal sanitation, food inspection, baths, drainage, etc. 3800 w. Eng Rec—Oct. 18, 1902. No. 51223.

Sewage.

A Dozen Years' Experience in Sewage Purification at Santa Rosa, Cal. Reviews the early experiences and describes the combination of septic tanks, settling tank, and upward filtration now in use. Ill. 1000 w. Eng News—Oct. 2, 1902. No. 50923.

Residential Septic Tanks. Burton J. Ashley. Presented to the Am. Soc. of

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Munic. Imp. Describes an arrangement for sewer service which proved an excellent septic tank, and the application of the idea on an extensive scale with satisfactory results. 2200 w. Eng Rec—Oct. 11, 1902. No. 51114.

Sewage Disposal Works at Nuneaton, England. Describes a system which deals successfully with sewage receiving waste from the works of wool scourers, fellmongers and hat factories. 1400 w. Eng Rec—Oct. 4, 1902. No. 50945.

The Purification of Sewage Water (Epuration des Eaux d'Egout). G. Richon. A discussion of the use of combined chemical and biological processes, as used in Belgium and in Austria. 2500 w. Génie Civil—Sept. 13, 1902. No. 51-301 D.

The Second Report of the Royal Commission on Sewage Disposal. Reviews the collection of reports issued by the commission, dealing with some of the bacterial phases of sewage and with the pollution and self purification of the River Severn. 4000 w. Eng News—Oct. 9, 1902. No. 51099.

The Treatment of Manchester Sewage. G. J. Fowler. Abstract of a paper read before the Sanitary Inst. Congress. Gives an account of experiments carried out to determine the best treatment for the sewage of this city, and the conclusions reached. 3200 w. Engng—Oct. 10, 1902. Serial. 1st part. No. 51173 A.

Sewers.

A Concrete-Steel Sewer. Describes and illustrates an interesting work to be constructed in Harrisburg, Pa. The sewer is to intercept the ordinary flow of a system of combined sewers in a district lying on both sides of a small stream which has been receiving these liquids. 3200 w. Eng Rec—Oct. 11, 1902. No. 51111.

An Important Main Drainage Scheme for Glasgow. A. B. McDonald. Notes describing the important scheme for the collection and treatment of sewage. 2000 w. Arch't, Lond—Oct. 3, 1902. No. 51-058 A.

WATER SUPPLY.

Aqueduct.

The Weston Aqueduct of the Metropolitan Water-Works, Boston. Alfred D. Flinn. Illustrates and describes details of the construction of an aqueduct designed for a capacity of 300,000,000 gals. per day, and nearly 13½ miles long. 4200 w. Eng Rec—Oct. 14, 1902. Serial. 1st part. No. 51220.

Brooklyn.

Proposed Further Development of Underground Water Supply for Brooklyn. I. M. de Varona. From the report of the N. Y. Dept. of Water Supply, Gas and Electricity for the quarter ending June 30, 1902. Illustrates different methods of collecting underground water, with outline of plan proposed. 1800 w. Eng News—Oct. 9, 1902. No. 51100.

Edinburgh.

The New Edinburgh Water-Works. An outline of the construction of Tolla reservoir, with the necessary pipe track, aqueducts and tunnels. The work may not be completed for three years, and may cost nearly one million sterling. It will add 10,000,000 gallons a day to the present supply. 2500 w. Engr, Lond—Oct. 3, 1902. No. 51088 A.

Irrigation.

Irrigation in South Africa. Extracts from the report of W. Willcocks, who was sent to examine the irrigation possibilities of Cape Colony, the Orange River Colony and the Transvaal. 3400 w. Jour Soc of Arts—Oct. 10, 1902. No. 51155 A.

The Scope and Purpose of the Irrigation Investigations of the Office of Experiment Stations. Elwood Mead. From the report of the office of Experiment Stations. Relates the investigations made of the arid and subhumid portions of the United States, and its insular possessions. 6000 w. Eng Rec—Oct. 18, 1902. No. 51224.

Pollution.

Stream Pollution and Its Pecuniary Damage to Natural Water Resources. Marshall O. Leighton. Read before the Central States Water Works Assn. Shows the value of water as a source of wealth as long as unpolluted, and reviews the damage done to the Passaic river in New Jersey, giving an outline of the work of the division of hydrography of the United States Geological survey. 2000 w. Munic Eng—Oct., 1902. No. 50873 C.

Reservoirs.

A Reservoir Break at Camden, N. J. An account of a failure due to overfilling, with illustrations. 1000 w. Eng Rec—Oct. 11, 1902. No. 51112.

The Failure of the Water-Works Dam at Utica, N. Y. Particulars of the accident, with photographs. The cause seems to be in the material used in making the upper 25 ft. at the north end of the dam. 700 w. Eng News—Oct. 9, 1902. No. 51096.

Submerged Mains.

Submerged Pipe. A. L. Holmes. Read before the Central States Water Works Assn. Considers methods of laying the pipes, and their care and protection; and difficulties and troubles due to improper work. 2000 w. Munic Engng—Oct., 1902. No. 50874 C.

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ELECTRICAL ENGINEERING

COMMUNICATION.

Automatic Systems.

Automatic Telephone System (Vollautomatisches Nebenstellensystem für Fernsprechanlagen). J. Baumann. A description of the improved equipment of the German Post Office telephone system. 5000 w. Elektrotech Zeitschr—Oct. 9, 1902. No. 51364 B.

Faller Automatic Telephone Exchange. An illustrated description of this system. 2500 w. Sci Am—Oct. 11, 1902. No. 51052.

Cables.

Dr. Muirhead's New Mode of Transmission and Relay for Cables. John Munro. Begins a description of this invention, giving an account of the work in this field. 2200 w. Elec Rev, Lond—Oct. 3, 1902. Serial. 1st part. No. 51083 A.

Light-Telephony.

Recent Experiments in Light Telephony (Neuere Versuche mit Lichtelephonie). Ernst Ruhmer. Describing experiments recently conducted on the Wannsee, near Berlin. Communication was had for a distance of 3.8 kilometres by means of light waves received by a telephone. 3000 w. Elektrotech Zeitschr—Sept. 25, 1902. No. 51356 B.

Multiplex Telegraphy.

The Rowland Multiplex System of Page Printing Telegraphy. Illustrated detailed description of the system invented by Prof. Henry A. Rowland. 3300 w. Sci Am—Oct. 25, 1902. No. 51291.

The Rowland Rapid Telegraph System. Begins an illustrated detailed description of this system and its operation. It is a multiplex duplex system, having a capacity of four different signals each way on one wire in one-quarter second. 3700 w. Elec Wld & Engr—Oct. 18, 1902. Serial. 1st part. No. 51197.

Printing Telegraph.

The Electric Typograph (L'Electro-Typographe). A. Lavezzari. A description of the Meray-Rozar apparatus by means of which a composing machine may be operated electrically at a distance. 6000 w. Mem Soc Ing Civ de France—Aug., 1902. No. 51327 G.

Space Telegraphy.

A Review of Wireless Telegraph Engineering Practice. A. Frederick Collins. A discussion of the basic principles of space telegraphy followed by fully illustrated descriptions of the principal systems. 6000 w. Engineering Magazine—November, 1902. No. 51397 B.

Apparatus of the Braun-Siemens & Halske System of Wireless Telegraphy. Illustrated detailed description. 2000 w. Elec Wld & Engr—Oct. 4, 1902. No. 51022.

Magnetic Detectors in Space Telegraphy. Ernst Wilson. Read at the Belfast meeting of the British Assn. Describes experimental investigations. 1100 w. Elec Engr, Lond—Sept. 19, 1902. No. 50851 A.

Signaling Through Space Without Wires. A. Frederick Collins. Discussing the various claims made by investigators as to priority. 2000 w. Elec Wld & Engr—Sept. 27, 1902. No. 50844.

Some New Detectors for Wireless Telegraphy. A. Frederick Collins. Illustrates and describes various new types, stating the advantages claimed. 1800 w. Sci Am—Oct. 4. 1902. No. 50936.

The De Forest Wireless Telegraph System. Illustrates and describes features of this system. 1000 w. Elect'n, Lond—Oct. 3, 1902. No. 51076 A.

The Slaby-Arco System of Space Telegraphy (Apparecci Slaby-Arco per Radio-telegrafia). A general description of the system, with illustrations of the apparatus at Bremerhaven and on the "See Adler," and fac simile of received message. Two articles. 2000 w. L'Elettricita—Sept. 21, 28, 1902. No. 51381 each B.

Wireless Telegraphy by the DeForest System. A. Frederick Collins. Illustrated description of apparatus used in this American system, with particulars relating to it. 1500 w. Elec Rev, N. Y.—Oct. 25, 1902. No. 51272.

Wireless Telegraphy by the Slaby-Arco System. A. Frederick Collins. Illustrated detailed description of the apparatus used and of the theory of syntonized and multiplex spark telegraphy. 2500 w. Elec Rev, N. Y.—Sept. 27, 1902. No. 50840.

Wireless Telegraphy in Germany. An illustrated detailed description of the apparatus used in the Slaby-Arco system. 3000 w. U S Cons Rept, No. 1457—Sept. 30, 1902. No. 50834 D.

Telegraphy.

The Experiences of a Telegraph Engineer in Perak State, 1898-1901. D. P. Reid. An account of some of the troubles encountered in the Malay Peninsula. 2500 w. Elec Rev, Lond.—Oct. 3, 1902. Serial. 1st part. No. 51081 A.

Telephony.

A New Telephone Relay. Illustrates and describes a novel method of reinforc-

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ing telephone currents recently patented by Joseph Lyons. 1200 w. Sci Am Sup—Oct. 18, 1902. No. 51205.

Practical Telephony. This first of a series of articles explains some of the terms used. 1500 w. Telephony—Oct., 1902. Serial. 1st part. No. 51035.

The Future of the Telephone in the United Kingdom. J. E. Kingsbury. Read at Belfast meeting of the British Assn. A review of the history of telephony in England, endeavoring to remove misunderstandings and considering the features upon which the service depends. 5500 w. Elec Engr, Lond.—Sept. 19, 1902. No. 50850 A.

The Toledo Home Telephone Company. A. E. Dobbs. Reviews the history of telephony in this city and gives an illustrated description of this new company's building and its equipment. 2700 w. Elec Rev, N. Y.—Oct. 13, 1902. No. 51184.

DISTRIBUTION.

Conductors.

The Determination of the Section of Conductors (Détermination de la Section des Conducteurs). M. Warluzel. Giving formulas for the computation of electrical conductors for a great variety of arrangements, with examples of their application. 3000 w. Revue Technique—Sept. 25, 1902. No. 51309 D.

Conduits.

The Joint Use of Underground Conduits for High and Low Tension Wires. Charles F. Hopewell. Abstract of a paper read before the International Assn. of Munic. Elect'ns. Considers the causes of explosions and burnouts, and what the requisite separation should be between the high and low-tension wires to ensure safety. 2200 w. Eng News—Oct. 16, 1902. No. 51217.

Insulation.

See Electrical Engineering, Measurement.

Polycyclic Systems.

The Polycyclic Distribution of Electricity. Explains the term and states the claims made for the system. Especially considers the Arnold-Bragstad-laCour system, and the validity of their claims. 2000 w. Elec Rev, Lond.—Sept. 26, 1902. No. 50957 A.

Power Distribution.

Distribution of Energy for Tramway, Lighting, and Power Purposes. A résumé of the latest information available on the distribution of power over a moderate sized area. 12200 w. Elec Engr, Lond.—Oct. 17, 1902. No. 51417 A.

The "Midland" Electric Power Distribution. Begins an illustrated detailed description of the plant of this company, also describing the location, and giving information of general interest. 4200 w. Elect'n, Lond.—Oct. 3, 1902. Serial. 1st part. No. 51075 A.

Rotary Converters.

Notes on the Practical Working of Rotary Converters. J. R. Salter. An illustrated article aiming to demonstrate the flexibility of the rotary converter when employed in a combined alternating and continuous current station. 1900 w. Elec Rev, Lond.—Oct. 17, 1902. No. 51406 A.

Switch.

Improved Automatic Switch (Neue Selbstchalter). Max Vogelsang. An illustrated description of the new switch of Voigt & Haeffner, adapted for use with high-tension currents without danger. 3000 w. Elektrotech Zeitschr—Sept. 18, 1902. No. 51355 B.

Testing.

See Electrical Engineering, Measurement.

ELECTRO-CHEMISTRY.

Batteries.

Point of Cut-Off in a Battery Discharge. Carl Hering. A discussion of possible solutions of this question. 1800 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51134 D.

Calcium.

The Winning of Metallic Calcium (Verfahren zur Gewinnnung Metallischen Calciums). W. Borchers & L. Stockem. Describing experiments at the Technical High School at Aix-la-Chapelle in connection with the isolation of calcium in the electric furnace. 1200 w. Zeitschr f Elektrochemie—Oct. 2, 1902. No. 51342 G.

Carbide.

The Reaction Equations in the Reduction of Calcium Carbide (Die Reaktionsgleichung bei der Calciumcarbid Reduktion). Fr. von Kügelgen. A comment on the discussion of Dr. Neumann upon the production of calcium carbide. 1200 w. Zeitschr f Elektrochemie—Oct. 9, 1902. No. 51344 G.

The Reaction Equations in the Reduction of Calcium Carbide (Die Reaktionsgleichung bei der Calciumcarbid-Reduktion). Dr. B. Neumann. A review of the chemical reactions involved in the production of calcium carbide in the electric furnace. 1500 w. Zeitschr f Elektrochemie—Oct. 2, 1902. No. 51343 G.

Chlorates.

The Electrolytic Manufacture of Chlorates. John B. C. Kershaw. A review of early processes and the early development of this industry. 2000 w. Ill. Elec Rev, N. Y.—Oct. 4, 1902. No. 51013.

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Colloids.

Colloids. W. R. Whitney. A study of the electrical action of colloidal suspensions or solutions. 3000 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51136 D.

Conduction.

Electrolytic Conduction Without Electrodes. Carl Hering. Gives arguments supporting the belief that electrolytic conduction is possible. 2400 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51132 D.

Copper.

Electrolytic Recovery of Copper from Low-Grade Ores. N. S. Keith. Gives the conditions and considerations applied in the planning and erecting of works for the electrolytic method of recovering copper from the ores of a mine near New York City. 3300 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51135 D.

Electro-Metallurgical Problems. Alec. A. Beadle. The present article considers the problems relating to copper. 1700 w. Elec Rev, Lond.—Sept. 26, 1902. Serial. 1st part. No. 50960 A.

Düsseldorf.

The Industrial Applications of Electro-Chemistry at the Düsseldorf Exposition (Elektrochemie und Verwandte Gebiete auf der Ausstellung in Düsseldorf). H. Danneel. The first instalment of a complete review of the electrochemical exhibits at Düsseldorf. Serial. Part I. 4000 w. Zeitschr f Elektrochemie—Sept. 25, 1902. No. 51341 G.

Electric Furnace.

The Electric Furnace in Industrial Chemistry. Charles B. Jacobs. Considers the types of elctric furnace, the new products and their value in industrial chemistry, the advantages, etc. 4200 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51131 D.

The Preheating of the Charge for the Electric Furnace (Verfahren zur Vorwärmung der Beschikung Elektrischer Oefen). A. Muriel and A. Neuburger. Showing the economy which may be effected by preheating the charge, and illustrating a form of furnace for the purpose. 1200 w. Elektrochemische Zeitschr—Oct., 1902. No. 51345 G.

The Stassano Electric Furnace (Forni Elettrici Stassano). S. Luzzati. With illustrations of the Stassano electric furnace arranged for smelting iron; also its application to steel furnaces with rotating inclined hearth on the Pernot type. 1200 w. L'Elettricita—Oct. 5, 1902. No. 51382 B.

Electro-Chemistry.

The Electrochemical Industries. A general review of the present condition of these industries. Storage and primary batteries and electrotyping are not considered. 5000 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51130 D.

Electro-Metallurgy.

Needed Electrometallurgical Processes. The two problems referred to are a process for extracting copper from sulphide ores, and a process for treating zinc and lead ores. 900 w. Elec Rev, N. Y.—Oct. 25, 1902. No. 51271.

Lead Refining.

The Electrolytic Refining of Base Lead Bullion. Titus Ulke. Description of the process invented by A. G. Betts for refining lead bullion, noting its low working cost and high efficiency. 1500 w. Eng & Min Jour—Oct. 11, 1902. No. 51107.

Nitrification.

The Electric Nitrification of the Atmosphere. William Hand Browne, Jr. An illustrated description of the apparatus employed for the fixation of atmospheric nitrogen, and the chemical reaction under the electric arc. 3800 w. Elec Rev, N. Y. —Oct. 18, 1902. No. 51183.

Storage Batteries.

Deterioration of Storage Battery Plates. M. U. Schoop. Notes referring to an article by Prof. A. L. Marsh, and report of evidence gathered during ten years' practical experience. 1000 w. Elec Wld & Engr—Oct. 25, 1902. No. 51234.

Zinc.

Electrolytic Manufacture of Zinc. Translated from *Revue de Chimie Industrielle*. Reviews the different methods that have been utilized, the difficulties encountered, the progress made, etc. 4000 w. Sci Am Sup—Oct. 18, 1902. No. 51204.

ELECTRO-PHYSICS.

Alloys.

Metallic Conduction and the Constitution of Alloys. John Alexander Mathews. Reviews what has been accomplished by various investigators of the general applicability of the solution theory to the explanation of the properties of alloys. 3800 w. Elec Wld & Engr—Oct. 4, 1902. No. 51020.

Analogies.

Hydraulic Analogies of Inductance and Capacity Combinations. George T. Hanchett. An explanation of the behavior of current and voltage in circuits containing inductance and capacity. Ill. 2000 w. Cent Station—Oct., 1902. No. 51034.

Condensers.

Graphical Method of Determining the Discharge of a Condenser Through a Variable Self-Induction. E. W. Marchant. Abstract of a paper read before the Brit-

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ish Assn. The method is an extension of one described by Dr. Sumpner for determining the rise of current with a variable self-induction, to which a P. D. is suddenly applied. 700 w. Elec Rev, Lond.—Oct. 17, 1902. No. 51405 A.

Induction.

Unipolar Induction (Ueber Unipolare Induktion). H. Cahen. A review of the experiments of Hoppe, showing that the phenomena fall under similar laws, which have not yet been fully demonstrated. 5000 w. Elektrotech Zeitschr—Oct. 16, 1902. No. 51366 B.

Radiography.

Self Radiant Materials (Die Selbstthätig Strahlende Materie). S. Saubermann. A study of the various self-radiant substances and the phenomena which they exhibit; including the researches of Becquerel, Curie, Giesel, Schmidt, and others. 4500 w. Zeitschr d Oesterr Ing u Arch Ver—Oct. 10, 1902. No. 51325 B.

Static Effects.

Static Strains in High Tension Circuits, and the Protection of Apparatus. Discussion of Percy H. Thomas' paper. 5000 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51139 D.

Thunderstorms.

The Theory of Thunderstorms. Concerning the remarkable experiments of Herr Schmauss, as given in the *Annalen der Physik*, which explains the phenomena as due to the picking up of an excess of negative ions by the water drops. 1,000 w. Elec Rev, Lond.—Oct. 17, 1902. No. 51403 A.

Transformation.

The Theory of Current Transformation (Beitrag zur Theorie der Stromwendung). A. Rothert. An elaborate mathematical discussion, deriving formulas for computation, and accompanied with tables and diagrams for practical application. Two articles. 7500 w. Elektrotech Zeitschr—Sept. 25, Oct. 2, 1902. No. 51357 each B.

GENERATING STATIONS.

Alternators.

Some Notes on Alternator Design. John Denham. Read before the Cape Town Loc. Sec. of the Inst. of Elec. Engrs. Discusses types of alternators and sets forth the superiority of polyphase plant. Also editorial. 8000 w. Elect'n, Lond.—Sept. 26, 1902. No. 50962 A.

Synchronous Commutating Machines. A. S. M'Allister. Discusses rotary converters and double-current generators, making comparison with the capacities of alternating-current generators of different number of phases. 2200 w. Am Elect'n—Oct., 1902. No. 51024.

Armatures.

The Armature Reaction of Alternators. C. F. Guilbert. A discussion of the diagrammatic methods that have been proposed, especially those which approach nearest to exactitude; treating the subject from the standpoint of a designing engineer. 1000 w. Elec Wld & Engr—Oct. 25, 1902. Serial. 1st part. No. 51235.

The Calculation of Armatures. Reprint of a paper presented by Prof. Luigi Pasqualini at meeting of the Italian Assn. of Elec. Engrs. Discusses the question of the design of dynamos by a series of formulæ. Also editorial comment. 1500 w. Elec Wld & Engr—Oct. 18, 1902. No. 51196.

Costs.

The Cost of Energy in Electricity Supply. Alton D. Adams. A comparison of accurate figures from steam and water-power stations, showing the influence of local conditions upon the elements of cost. 2500 w. Engineering Magazine—November, 1902. No. 51392 B.

Double Current.

Double Current Generators and Rotary Converters. Sydney Woodfield. States the advantages of the double current generator, explaining where they will prove especially useful. 2800 w. Elec Rev, Lond.—Oct. 3, 1902. No. 51080 A.

Dynamos.

Leaves from a Testing Engineer's Note Book. Fred W. Davies. A brief statement of some of the faults which have occurred in dynamo-electric machines, with an explanation of them and the method adopted for their remedy. Shafts, bearings and armature cores are considered in the present article. 1500 w. Elec Engr, Lond.—Oct. 10, 1902. Serial. 1st part. No. 51160 A.

On the Specific Utilization of Materials in Dynamo Design. Prof. Sylvanus P. Thompson. Read before the British Assn. Considers this subject solely in relation to the armature. 1400 w. Elect'n, Lond.—Sept. 19, 1902. No. 50848 A.

The Making of a Dynamo. Henry A. Mavor. Abstract of a paper read at Belfast meeting of the Brit. Assn. Illustrates and describes the construction. 1600 w. Elec Rev, Lond.—Oct. 3, 1902. No. 51082 A.

Emden.

The Electric Plant of the Harbor of Emden (Die Elektrischer Anlage des Emder Hafens). H. Langner. With plan of the harbor, and illustrated description of the generating station and lighting and power installations. Two articles. 7000 w. Elektrotech Zeitschr—Oct. 2, 9, 1902. No. 51359 each B.

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Generating Sets.

Some Engines and Generators at the Düsseldorf Exposition. Illustrates and describes interesting exhibits. 2000 w. Am Elect'n—Oct., 1902. No. 51025.

Hydro-Electric Stations.

See Electrical Engineering, Generating Stations.

Isolated Plant.

Power Plant of the Cleveland Twist Drill Co. Illustrated detailed description of an interesting modern isolated plant. 2800 w. Engr, U. S. A.—Oct 1, 1902. No. 50911.

The New Power Plant for the Assabet Mills, Maynard, Mass. Illustrated description of an electric plant for driving a 5 and 6-story woolen mill, 600 x 106 ft. in plan. 3000 w. Eng Rec—Oct. 4, 1902. No. 50943.

Newark, N. J.

A Rebuilt and Enlarged Central Station. Illustrated description of the River Station of the United Electric Company of New Jersey, at Newark. 4000 w. Am Elect'n.—Oct., 1902. No. 51023.

Parallel Driving.

A few hints as to the Installation and Operation of Alternators in Parallel. Fred P. Woodbury. Helpful suggestions for the setting and operation of these machines. Ill. 3000 w. Am Elect'n—Oct., 1902. No. 51027.

Phase Shifting.

A New Method of Compensating for Phase Shifting in Non-Synchronous Alternators (Ein Neues Verfahren zum Kompensiren der Phasenverschiebung in Asynchronen Wechselstrommaschinen). M. Osnos. A review of the theories of Görges and Heyland, discussing them from the point of maximum economy. 2500 w. Elektrotech Zeitschr—Oct. 16, 1902. No. 51365 B.

Regulation.

Computation of Regulation of Alternating Current Generators. Virginius D. Moody. An explanation, illustrated by an example. 1600 w. Elec Wld & Engr—Oct. 18, 1902. No. 51198.

Speed Regulation.

See Mechanical Engineer, Steam Engineering.

LIGHTING.

Electricity and Gas.

See Gas Works Engineering.

Illumination.

Light and Illumination. E. L. Elliott. An elementary explanation of the principles of photometry and their application to the problems of illumination. 4300 w. Cent Station—Oct., 1902. Serial. 1st part. No. 51033.

Some Common Faults in Exterior Illumination. S. Everett Doane. Urging the use of incandescent lamps for residential streets, side streets, and outside the more congested portions of a town or city. 1200 w. Trans Am Inst of Elec Engrs—June-July, 1902. No. 51137 D.

See Gas Works Engineering.

Office Lighting.

Electric Lighting in the Union Trust Company's Building, Providence, R. I. The three-wire system installed makes use of its metallic conduits to replace the neutral wire, thus saving about 40,000 feet of wire, and, it is claimed, making it impossible for fire to start from an electrical source. Ill. 1200 w. Eng Rec—Oct. 25, 1902. No. 51241.

Train Lighting.

See Railway Engineering, Motive Power and Equipment.

MEASUREMENT.

Calibration.

A Selection for Measurement and Calibration of Alternating Apparatus (Ein Wechselspannungswähler für Mess und Aichzwecke). C. Heinke. Describing a form of variable transformer, adapted for purposes of alternating current measurement. 1800 w. Elektrotech Zeitschr—Oct. 2, 1902. No. 51361 B.

Chronograph.

Apparatus for Determining the Sensitiveness of the Chronograph (Uebereinen Apparat zur Empfindlich Keitsvestimmung des Chronographen). R. F. Pozdena. The time intervals are magnified mechanically, and the indications of the chronograph under test are recorded electrically upon the same plate for comparison. 2000 w. Elektrotech Zeitschr—Oct. 9, 1902. No. 51363 B.

Instruments.

Some Novelties in Electrical Apparatus. M. B. Field. Read at Belfast meeting of the Brit. Assn. States the objects these instruments are intended to serve. Deals with a compensated voltmeter, hot-wire wattmeter, fault indicator, and synchronizing gear. 1200 w. Elect'n, Lond—Oct. 3, 1902. No. 51077 A.

Insulation.

The Measurement of Insulation in Operating Continuous-Current Installations (Isolationsmessung an in Betrieb befindlichen Gleichstrom anlagen). Dr. Th. Bruger. Describing the method of employing a separate auxiliary current passing through a resistance to the earth, and measuring the extent to which the latter current is neutralized by the leakage from

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the main current. 1500 w. Elektrotech Zeitschr—Oct. 9, 1902. No. 51362 B.

Measuring Device.

A New Form of Measuring Apparatus and its Application (Ein Neues Messgerath und seine Verwendung). G. Dietze. Describing a combination of a spool wound with insulated wire and of a telephone; showing how this simple appliance may be used to detect faults and to make other measurements of current with much convenience. 3500 w. Elektrotech Zeitschr—Sept. 18, 1902. No. 51354 B.

Polyphase.

The Predetermination of the Fall of Pressure in Polyphase Generators (Vorausbestimung des Spannungsabfalles von Drehstrom generatoren). F. Kesselring. Describing the construction of polar diagrams from which the problem can be solved graphically. 1500 w. Elektrotech Zeitschr—Oct. 2, 1902. No. 51360 B.

Potentiometer.

Liquid Potentiometer; Determining Electrolytic Resistances with Direct Current Instruments. Carl Hering. Describes a liquid potentiometer and the methods of using it. 2500 w. Trans Am Inst of Elec Engrs—June and July, 1902. No. 51133 D.

Testing.

Testing and Other Things. N. C. Woodfin. An inquiry into the meaning and object of testing electrical apparatus, and things related to this work. 1200 w. Elec Rev, Lond—Oct. 17, 1902. Serial. 1st part. No. 51404 A.

POWER APPLICATIONS.

Alternating Motors.

Alternating Current Motors. A brief description of the characteristics of these motors. 1100 w. Elec Rev, N. Y.—Oct. 18, 1902. No. 51182.

Iron Works.

Electrical Equipment of Antwerp Iron and Steel Works. A brief illustrated account of an interesting plant in Belgium. The extent of the electric drive and the variety of runs to which it is put is a study in the shop equipment of a modern manufactory. 1600 w. Elec Wld & Engr—Oct. 18, 1902. No. 51199.

The Antwerp Steel and Iron Works (Forges et Aciéries d'Anvers). A description of the new steel works under construction at Hoboken, near Antwerp. All the machinery, including the heavy rolls, is to be driven by electric power. 2500 w. Revue Technique—Sept. 10, 1902. No. 51307 D.

The Application of Electric Power in the Iron and Steel Industries. D. Selby-Bigge. Gives facts and figures of a practical nature collected from many sources. 3500 w. Elect'n, Lond—Oct. 3, 1902. Serial. 1st part. No. 51079 A.

The Use of Electricity in Iron and Steel Works. E. Kylberg. Read at the Düsseldorf meeting of the Iron & Steel Inst. Illustrates and describes some developments based on American practice and adapted to European requirements. 2500 w. Mech Eng—Sept. 20 and 27, 1902. 2 parts. No. 50949 each A.

Machine Driving.

Comparative Tests of Independent and Group Driving (Einige Prüfungs resultate des Elektrischen Gruppen und Einzel-Antriebes). H. V. Reichel. Data and results of tests made at the Pruschkowo shops of the Vienna-Warsaw railway, showing the most favorable conditions of either system. 3000 w. Glasers Annalen—Oct. 15, 1902. No. 51340 D.

Mining Plant.

The Electric Plant of the Boléo Mines (Installations Electriques des Mines du Boléo). E. Hoffman. A general description of the power house and distribution of the electric system at Santa Rosalia, Mexico. 2000 w. Génie Civil—Sept. 27, 1902. No. 51303 D.

Motor Control.

The Control of Electrical Motors in Factories. N. C. Woodfin. Discusses switches and methods of control arguing that bad systems have hindered the adoption of electric motors. 1800 w. Elec Rev, Lond—Sept. 19, 1902. No. 50853 A.

Pumping.

Electric Pumping Station for Sewage Disposal. Illustrated description of a fine plant at Pittsfield, Mass., which is probably the first electrically-driven pumping station for sewage disposal in the United States. 900 w. Elec Wld & Engr—Oct. 18, 1902. No. 51195.

Single-Phase Pumping Plant, Hammersmith. Illustrates and describes a plant installed to pump Thames water for condensing purposes to an elevated cast-iron tank some 700 yards distant. 2000 w. Elec Rev, Lond—Sept. 26, 1902. No. 50958 A.

Steering.

Electrical Steering Apparatus for Ships. George McQuilkin. An illustrated explanation of the operation of this apparatus. 2500 w. Marine Engng—Oct., 1902. No. 51012 C.

Telpherage.

Piscicelli Taeggi's Electric Post. William P. Digby. Brief illustrated description of a system now under the consideration of an expert committee in Rome, Italy, for the transmission of letters,

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newspapers and parcels along an electric aerial railway at speeds as high as 400 kilometres per hour. 1800 w. Engng—Sept. 26, 1902. No. 50972 A.

TRANSMISSION.

High Potential.

Electric Power Installation Near Butte, Montana. An illustrated article describing a plant using a 50000 voltage, owned by the Missouri River Power Company. 3200 w. Sci Am Sup—Oct. 18, 1902. No. 51203.

Long Distance.

Long Transmission from a Steam Station for Electric Traction. Illustrates and describes a system, the main purpose of which is to operate electric car lines for a distance of 50 miles, but also furnishes current for Portsmouth, N. H., and other points. 6200 w. Elec Wld & Engr—Oct. 11, 1902. No. 51121.

Rise of Electrical Transmission. Alton D. Adams. A description of some of the largest long-distance transmissions of electrical energy in the world. 5000 w. Ill. Mines & Min—Oct., 1902. No. 51044 C.

The Swan Falls Trade Dollar Transmission. An illustrated detailed description of the transmission plant built to furnish power for the Trade Dollar Mines. The pole line is 32 miles in length. 1500 w. Jour of Elec—Oct., 1902. No. 51191 C.

Switzerland.

Electric Power Transmission and Supply in Switzerland. Illustrates and describes features of Swiss practice observed during a series of recent visits. 2800 w. Engr, Lond—Sept. 26, 1902. Serial. 1st part. No. 50966 A.

GAS WORKS ENGINEERING

Acetylene.

How to Fit Up a Complete Acetylene Plant. F. Dye. Gives information helpful in choosing a generator, and describes the arranging and fitting of the plant. 2400 w. Plumb & Dec—Oct. 1, 1902. No. 51068 A.

Ammonia.

Manufacture of Sulphate of Ammonia. R. T. Stoddard. Read before the Manchester and District Junior Gas Assn. Describes, in a general way, the apparatus required and method of working. 4800 w. Jour Gas Lgt—Oct. 7, 1902. No. 51164 A.

Analysis.

The Analytical Valuation of Gas Coals. G. P. Lishman. Read before the Inst. of Min. Engrs. Also a critical editorial. Describes the apparatus in use at Lambton, the difficulties met and means used to remove them. Ill. 5000 w. Gas Wld—Oct. 4, 1902. No. 51073 A.

Burners.

Lighting Gas, and How Best to Burn It. Walter Grafton. Discusses the use of burners that will secure economy and efficiency. 1500 w. Plumb & Dec—Oct. 1, 1902. No. 51067 A.

Carbide.

See Electrical Engineering, Electrochemistry.

Charging Apparatus.

The Rapid Charging and Drawing Apparatus. J. W. Russell Wall. Read before the Eastern Co.'s Gas Mgrs. Assn. An explanation of this apparatus for charging retorts, followed by general discussion. 5200 w. Jour Gas Lgt—Sept. 23, 1902. No. 50883 A.

Combination.

Gas and Electricity Departments in Combination. S. Meunier. Read before the Midland Assn. of Gas Mgrs. Considers the advantages of such a combination. Also discussion. 7000 w. Jour Gas Lgt—Oct. 14, 1902. No. 51249 A.

Earnings.

The Earnings of a Ton of Gas Coal. C. E. Jones. The inquiry is limited to coal subjected to destructive distillation in the usual manner in the works of gas companies in the United Kingdom. 1800 w. Jour Gas Lgt—Oct. 14, 1902. No. 51247 A.

Explosions.

Movements of the Flame in the Explosion of Gases. Harold B. Dixon. Abstract of a paper read before the Royal Society. An account of experimental study in the field. 6000 w. Am Gas Lgt Jour—Oct. 13, 1902. No. 51119.

Ferrocyanide.

Ferrocyanide Manufacture at the Hague Gas-Works. Extract from a paper by Heer J. Rutten, in *Het Gas*, giving an account of a process in practical operation for the production of potassium ferrocyanide from the cyanogen in coal gas. Ill. 3800 w. Jour Gas Lgt—Sept. 30, 1902. No. 51031 A.

Gas Heating.

On the Use of Gas for Warming Inclosed Space. Dr. W. H. Birchmore. Discusses how best to heat with economy and success by means of illuminating gas. 5000 w. Am Gas Lgt Jour—Oct. 27, 1902. No. 51258.

We supply copies of these articles. See page 495.

Temperature and the Output of Gas-Fires: Is It Colder Before or After Christmas. An article prepared from notes drafted by E. W. T. Richmond just previous to the recent fatal accident. Considers the effect of temperature on gas consumption, giving facts in proof that it is colder during the late winter months. 5000 w. Jour Gas Lgt—Sept. 30, 1902. No. 51030 A.

The Heating Effect of Gas. W. R. Crane. Description of an improved method and apparatus for determining heating values. Ill. 4000 w. Mines & Min—Oct., 1902. No. 51045 C.

Gasholder.

Cable-Guided Gasholder at the Rodez Gas-Works. M. Godinet. Read before the Société Technique du Gas en France. An illustrated article describing this system and giving results of tests made. 2300 w. Jour Gas Lgt—Sept. 23, 1902. No. 50885 A.

Gas Power.

See Mechanical Engineering, Special Motors.

Handling.

Apparatus for Handling Coal and Iron (Technische Hülfsmittel zu Befördern und Lagerung von Kohlen und Eisenerzen). M. Buhle. Describing especially the appliances in use at the Charlottenburg gas works. 1500 w. Zeitschr d Ver Deutscher Ing—Sept. 27, 1902. No. 51315 D.

Illumination.

Recent Improvements in the Art of Lighting and Heating (Neuerungen auf dem Gebiete des Beleuchtungs- und Beheizungswesens). Franz Walter. Discussing especially improved methods of lighting by gas, with a brief reference to heating. Two articles, 7500 w. Zeitschr d Oesterr Ing u Arch Ver—Sept. 19, 26, 1902. No. 51323 each B.

See Electrical Engineering, Lighting.

Improvements.

Recent Improvements at the Chester Gas Works. John C. Belton. Read before the Midland Assn. of Gas Mgrs. An account of the work of modernizing the retort house, and some of the difficulties encountered. Ill. 5200 w. Jour Gas Lgt—Oct. 14, 1902. No. 51248 A.

Incandescence.

The Incandescent Burner in the Church. J. H. Troughton. Gives the writer's experience gained in successfully lighting some of the churches of Newmarket with incandescent burners. 1100 w. Jour Gas Lgt—Sept. 23, 1902. No. 50882 A.

Theory of the Incandescent Mantle. A. H. White and A. F. Traver. Gives data on the temperature of the flame and the mantle, the relation existing between the temperature and illumination, and discusses whether the illumination is a pure temperature effect. 5800 w. Pro Age—Oct. 15, 1902. No. 51141.

Mains.

Methods Employed in the Construction and Maintenance of the Massachusetts Pipe Line Gas Co.'s Mains in Boston and Vicinity. W. W. Cummings. Describes methods adopted to keep the cost within required limits. Ill. 2300 w. Eng News—Oct. 2, 1902. No. 50922.

New Zealand.

Incandescent Gas Lighting in Wellington, New Zealand. R. G. Howell. An explanation of the system adopted to meet keen competition with the electric light. Ill. 2700 w. Jour Gas Lgt—Sept. 23, 1902. No. 50881 A.

Pipe Corrosion.

See Street and Electric Railways, Stray Currents.

Purifiers.

The "Millbourne" and "Prins van Diesburgh" Systems of Purifiers. An illustrated description of the system devised by Herr J. J. Prins van Diesburgh, with remarks of Herr C. T. Salomons on its similarity with the Millbourne system. 1300 w. Jour Gas Lgt—Sept. 23, 1902. No. 50886 A.

Rates.

Gas Rates and Franchise Tax. George McLean. Read at meeting of the Am. Gas Lgt. Assn. An explanation of the laws of Iowa as bearing on these questions. 2000 w. Am Gas Lgt Jour—Oct. 20, 1902. No. 51185.

Retorts.

Inclined Retorts at the Vaise (Lyons) Gas-Works. M. Godinet. Read before the Société Technique du Gas en France. An illustrated description of the inclined retort-house recently installed and its working. 6300 w. Jour Gas Lgt—Sept. 23, 1902. No. 50884 A.

Slot-Meters.

Some of the Questions Involved in the Slot-Meter System Considered. George Helps. Read before the Midland Assn. of Gas Mgrs. Considers the service at the present time and submits certain propositions which are discussed. 8500 w. Jour Gas Lgt—Oct. 14, 1902. No. 51250 A.

Water Gas.

The Outlook for Carburetted Water Gas. The present article considers some of the recent working results, the departmental committee's recommendations, costs, etc. 3000 w. Gas Wld—Oct. 11, 1902. Serial. 1st part. No. 51159 A.

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INDUSTRIAL ECONOMY

Benefit Associations.

See Street and Electric Railways.

Coal Trade.

The Production, Consumption, Imports and Exports of the World's Coal Trade. Information from the annual statement prepared by the British Board of Trade. 2700 w. Ir & Coal Trds Rev—Oct. 10, 1902. No. 51165 A.

Coke Production.

See Mining and Metallurgy, Coal and Coke.

Education.

The Manchester Municipal School of Technology. An elaborately illustrated article giving a detailed description of this new building and its fine equipment. 16000 w. Engng—Oct. 10, 1902. No. 51168 A.

The Present Industrial Importance of Technical Education. Sir Philip Magnus. A review of the relation of technical education to commercial supremacy, with reference to the foresight of Germany as compared with Great Britain. 4000 w. Engineering Magazine—November, 1902. No. 51391 B.

Germany.

See Mining and Metallurgy, Iron and Steel.

Labor.

Labor Organizations in the United States. Carroll D. Wright. Reviews the development of trade-unionism in the United States, and its present standing. 4200 w. Contemporary Rev—Oct., 1902. No. 51152 D.

Shipping Combine.

The Atlantic Shipping Trade. Editorial discussion of the recently formed association to be known as the International Mercantile Marine Company, considering mainly its naval aspect. 3000 w. Engng—Oct. 10, 1902. No. 51169 A.

Strike.

Mistakes of the Anthracite Operators. Criticises their failure to conciliate public opinion, and their lack of tact. 900 w. Eng & Min Jour—Oct. 25, 1902. No. 51236.

Report to the President on the Anthracite Coal Strike. Carroll D. Wright. Considers the origin, demands, claims and complaints, wages and cost of production, etc., with suggestions. 36500 w. Bul Dept of Labor—Nov., 1902. No. 51028 D.

Settlement of the Anthracite Miners' Strike. Details of the settlement are given. 2000 w. Eng & Min Jour—Oct. 18, 1902. No. 51206.

The American Strike: Its Causes and Its Influences. Discusses the miner's wages in the United States, the quality of the coal, the influence on British prices, and the tariff. 3800 w. Ir & Coal Trds Rev—Oct. 10, 1902. No. 51166 A.

Wages.

The False Economy of a Low Wage Rate. Percy Longmuir. Showing the inefficiency of cheap labor, and the wastefulness of ill-nourished workers, as compared with the productiveness of higher paid workmen. 3500 w. Engineering Magazine—November, 1902. No. 51396 B.

MARINE AND NAVAL ENGINEERING

Cruisers.

Launch of the Des Moines. Illustration with particulars relating to the construction and equipment of this cruiser. 2000 w. Naut Gaz—Sept. 25, 1902. No. 50841.

The French Armored Cruiser Kleber. Illustrated description of one of three 7700 tons cruisers of a novel type. 1000 w. Engr, Lond.—Oct. 3, 1902. No. 51090 A.

The Latest British Armored Cruiser "Good Hope." Illustration and interesting comparisons of this first of a class of fast and powerful cruisers, with earlier vessels. 1000 w. Sci Am—Oct. 18, 1902. No. 51200.

Destroyers.

U. S. Torpedo-Boat Destroyers Truxton, Whipple and Worden. An illustrated description of one of these three identical boats, the armament, and report of trials. 1400 w. Marine Engng—Oct. 1902. No. 51006 C.

Electric Steering.

See Electrical Engineering, Power Applications.

Firing.

Firing on Ocean Steamships. Lawrence Irwell. Remarks on the service, class of men, their accommodations at sea, and customs, especially on English ships. 3000 w. Marine Rev—Sept. 25, 1902. No. 50833.

Fog Signals.

Experiments at St. Catherine's with Fog Signals. H. C. Fyfe. An illustrated article giving an account of a series of tests mainly devoted to comparisons of effi-

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ciency between the siren principle and the reed principle of producing sound. 900 w. Sci Am—Oct. 11, 1902. No. 51054.

Gunboats.

The New American-Built Mexican Gunboats. Illustrated description. 900 w. Naut Gaz—Sept. 25, 1902. No. 50842.

Life-Boats.

New Life-Saving Boat in Norway. Brief description of a new lifeboat which has just been tried with satisfactory results. 450 w. U S Cons Repts, No. 1472—Oct. 18, 1902. No. 51150 D.

The Dickenson Improved Life Boat. Illustrated description of a novel boat constructed of metallic sheets, self-bailing and self-righting. 700 w. Am Shipbuilder—Oct. 9, 1902. No. 51049.

Liners.

The Launch of the White Star Liner "Cedric." Harold J. Shepstone. Illustrations with brief description of this vessel the largest ship ever built. 900 w. Sci Am Sup—Oct. 11, 1902. No. 51055.

The New Atlantic Liners. Concerning the new fast vessels to be built by the Cunard Company, discussing the vessels already in service which have at different times lowered the record across the Atlantic. 3700 w. Engr, Lond.—Oct. 17, 1902. No. 51421 A.

Shipping Combine.

See Industrial Economics.

Stability.

Stability of an Oil-Tank Steamer. P. F. Walker. Investigations of the effect of liquids in a ship when the containing tanks or compartments are not completely filled. 2500 w. Marine Engng—Oct., 1902. No. 51007 C.

Steamboat.

New Steamboat Maryland. Illustration and description of a fine passenger vessel just completed for service on Chesapeake Bay. 1600 w. Naut Gaz—Oct. 2, 1902. No. 50996.

Tail-Shafts.

Suggestions as to the Prevention of Corrosion of Tail-End Shafts. John Boddy. Read before the Inst. of Marine Engrs. Describes appliances used for the prevention of corrosion, and a system of lubricating such shafts, giving results attained. Also discussion. 2500 w. Marine Engng—Oct., 1902. Serial. 1st part. No. 51009 C.

Tender.

United States Lighthouse Tender Magnolia. Illustrated description of a new vessel to be used in the Gulf of Mexico and lower Mississippi. A departure in design has been made to meet the conditions of that climate. 1100 w. Marine Rev—Oct. 23, 1902. No. 51257.

Testing Tank.

The North German Lloyd Testing Tank at Bremerhaven (Die Schiffbau-Technische Versuchsstation des Norddeutschen Lloyd in Bremerhaven). A. Schromm. With views of the tank and model rooms and diagrams of the recording apparatus. 2000 w. Oesterr Wochenschr f d Oeffent Baudienst—Oct. 4, 1902. No. 51369 B.

U. S. Navy.

Report on Naval Construction. Abstract of the report of Admiral F. T. Bowles concerning work on new vessels, repairs, improvement in plants, etc. 2000 w. Ir Age—Oct. 16, 1902. No. 51142.

MECHANICAL ENGINEERING

AUTOMOBILES.

Berlin Exhibition.

The German Automobile Exposition at Berlin, 1902 (Die Deutsche Automobil-Ausstellung zu Berlin, 1902). With illustrations of the various motor cycles and automobiles shown at the recent exhibition. Two articles, 3000 w. Glasers Annalen—Sept, 15, Oct. 1, 1902. No. 51338 each D.

Electric Cars.

Electrically-Propelled Motor Cars. Illustrates and describes some of the vehicles of the British Electromobile Company, and discusses some of the advantages and disadvantages of electric cars. 3000 w. Elect'n, Lond—Sept. 19, 1902. No. 50847 A.

Fore-Carriage.

A Novel Automobile Fore-Carriage. From *La Locomotion.* An illustrated description of a novel mechanism which transforms the usual horse-drawn vehicles into motor machines, and is also used on automobiles giving great facility in steering and operation. 3800 w. Sci Am Sup—Oct. 11, 1902. No. 51056.

French Designs.

The Automobile in 1902 (L'Automobile en 1902). G. Lavergne. The first of a series of articles discussing in detail the latest improved forms of French automobiles. The first instalment treats of the

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elements of the internal combustion motor for automobiles. 6000 w. Rev Gen des Sciences—Sept. 15, 1902. No. 51380 D.

Generators.

A Home Made Generator and Pilot Light. W. P. Haines. Illustrates and describes a successful arrangement of auxiliary gasoline burner for steam automobiles, devised by the writer and made at small cost. 2000 w. Horseless Age—Oct. 8, 1902. No. 51036.

Hill-Climbing.

The Chateau-Thierry Hill Climb. An illustrated account of very successful trials. 1000 w. Autocar—Oct. 4, 1902. No. 51066 A.

The Gaillon Hill-Climbing Trials. An illustrated account with report of results. 1800 w. Autocar—Oct. 18, 1902. No. 51413 A.

The Gaillon Hill-Climbing Trials. An illustrated account. Also of the Mont Ventoux climb. 2800 w. Autocar—Sept. 27, 1902. No. 50953 A.

Ignition.

Alternating Current System of Ignition. Albert L. Clough. Remarks on Mr. Bramwell's proposal for this system of ignition, with brief discussion of other devices. 1000 w. Horseless Age—Oct. 22, 1902. No. 51266.

Charging Ignition Accumulator Cells. Explains methods of charging from a private plant, public supply, and when neither of these sources is available. 3000 w. Auto Jour—Oct. 18, 1902. No. 51411 A.

Military Vehicles.

The War Office Committee's Report on Military Self-Propelled Lurries. Extracts from this report, with remarks, 3300 w. Auto Jour—Sept. 20, 1902. No. 50857 A.

Motor Cars.

Oil Motor Cars for 1902. C. C. Longridge. Considers points in the principles of construction of petrol cars as at present manufactured. Ill. 21500 w. Inst of Mech Engrs—Oct. 17, 1902. No. 51427 D.

The Maudslay 20 H. P. Car. Begins an illustrated detailed description of a car containing new features. 900 w. Autocar—Oct. 18, 1902. Serial. 1st part. No. 51412 A.

Petrol Cars.

The Ariel Petrol Cars. The first of a series of illustrated articles describing interesting vehicles made in Birmingham, England. 900 w. Auto Jour—Sept. 20, 1902. Serial. 1st part. No. 50855 A.

The New 16 h. p. De Dietrich Car. An illustrated description of new cars built under Turcat-Méry patents. 1200 w. Autocar—Oct. 4, 1902. No. 51064 A.

Petrol Motors.

Cylinder Lubrication in Petrol Motors. C. C. Longridge. Discusses the maximum working temperature of the cylinder walls and the maximum stability of the oil under heat. 1400 w. Autocar—Oct. 4, 1902. No. 51065 A.

Pleasure Vehicles.

The Motor Manufacturing Company's Cars. Illustrates and describes three recently built types, of 8, 10, and 20 h. p. respectively. 1800 w. Auto Jour—Oct. 11, 1902. No. 51156 A.

Racing Car.

Peerless Racing Car. Illustrated detailed description of the 1903 model. 2200 w. Auto & Motor Rev—Oct. 11, 1902. No. 51050.

The Truffault Racer. From *La Locomotion.* Brief illustrated description of an interesting experimental machine. 500 w. Sci Am—Oct. 4, 1902. No. 50940.

Reliability Run.

Boston Reliability Run. Gives itinerary and road description of the New York-Boston reliability run which begins on Oct. 9, 1902. 2800 w. Auto Topics—Oct. 4, 1902. No. 50917.

Conclusions on the Reliability Contest. Albert L. Clough. Remarks on the New York-Boston run, unreliable parts, lubrication, etc. 1500 w. Horseless Age—Oct. 22, 1902. No. 51265.

Impressions Gained from the Run—Features of Construction. Hugh D. Meier. Remarks on Springs, axles, wheels and tires, chains and transmissions, etc. 2200 w. Horseless Age—Oct. 22, 1902. No. 51268.

New York-Boston Reliability Run. An illustrated account of the recent test run. 3700 w. Auto Topics—Oct. 18, 1902. No. 51151.

The A. C. A. 500 Mile Reliability Run from New York to Boston and Return. An illustrated general report. 9000 w. Horseless Age—Oct. 15, 1902. No. 51180.

The Reliability Trial from a Technical Point of View. The present article gives illustrated brief descriptions of the competing vehicles, general criticisms, etc. 7300 w. Auto Jour—Sept. 20, 1902. Serial. 1st part. No. 50856 A.

The 650 Miles Reliability Trials. An explanation of how the marks were lost on the road, as far as now known; speeds and times accomplished on the test hills; with observations on the trials, by Henry Sturmey. 7000 w. Autocar—Sept. 20, 1902. No. 50858 A.

Repairs.

The Item of Repairs. Dr. Daniel Longaker. Remarks on points in design that

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need attention. 1800 w. Horseless Age—Oct. 22, 1902. No. 51267.

Rules.

Reliability Trial Rules. Gives tabulated results showing the effect of a system of rules based upon speed, number of passengers, fuel consumption and cost of vehicle. Also editorial and report of the revised official marks and the judges' awards. 4400 w. Auto Jour—Oct. 11, 1902. No. 51157 A.

Touring Car.

The Rochet Touring Car. Illustrates and describes the latest type of touring car. It has a gas motor, and the power transmission and action of gears is explained. 1500 w. Autocar—Sept. 27, 1902. No. 50952 A.

Tires.

Tyre Manipulation. Illustrated instructions referring to tyres having thickened edges. 1700 w. Autocar—Sept. 20, 1902. No. 50859 A.

Traction.

Traction of Road Vehicles. Information from a committee report presented at the Belfast meeting of the Brit. Assn. on the resistance of road vehicles to traction. Illustrates the apparatus by which investigations were carried on. 3500 w. Engng—Oct. 3, 1902. No. 51092 A.

Voiturette.

The Swift Voiturette. Illustrates and describes the distinctive features of this vehicle. Its weight is 8½ cwt. 2500 w. Auto Jour—Oct. 18, 1902. No. 51410 A.

HYDRAULICS.

Electric Pumping.

See Electrical Engineering, Power Applications.

Flow.

The Flow of Water in Wood Pipes. Discussion of paper by Theron A. Noble. 4300 w. Pro Am Soc of Civ Engrs—Oct., 1902. No. 51255 E.

Hydraulic Power.

The "White Coal" Congress (Le Congrès de la "Houille Blanche"). J. A. Montpellier. A report of the convention recently held in France for the discussion of the development of the hydraulic power of the French Alps. Serial. Part I. 3000 w. L'Electricien—Oct. 11, 1902. No. 51384 B.

Hydro-Electric.

Electrical Supply from Water Power. Alton D. Adams. Points out the extent to which small water powers, and parts of larger ones, have been applied to systems of electrical supply in Massachusetts. 1000 w. Elec Wld & Engr—Oct. 4, 1902. No. 51019.

Progress on Power Station No. 2 of the Niagara Falls Power Company. Photographs showing the progress of this work, which will soon be ready for operation, with explanatory notes. 800 w. Eng News—Oct. 2, 1902. No. 50920.

The Big Bend Tunnel for Power Development. Franklin Riffle. Gives the history of this tunnel which was a disastrous mining failure, and an account of its recent utilization for power development, in which it promises great commercial success. 1200 w. Sci Am—Oct. 11, 1902. No. 51053.

The Sault Ste. Marie Water Power. Frank C. Perkins. Illustrations showing the power canal and power house during construction, with interesting information concerning this great work. 1700 w. Elec Wld & Engr—Sept. 27, 1902. No. 50843.

Plumbing.

Plumbing in the Flat Iron Building, New York. Illustrated description of the work in a building of triangular plan, rising 285 feet above the street and exposed on its three sides. 2500 w. Eng Rec—Oct. 4, 1902. No. 50948.

The Theory and Practice of Plumbing. Charles L. Hubbard. The first of a series of illustrated articles designed to be helpful to both the apprentice and skilled mechanic. 1000 w. Dom Engng—Oct. 25, 1902. Serial. 1st part. No. 51259 C.

Pumps.

The Pumping of Slimes and Sands. L. J. Charles. Illustrations of various sand pumping devices, with figures in regard to the capacities, power used and limitations or conditions, under which each gives the best satisfaction. 1200 w. Min Rept—Oct. 9, 1902. Serial. 1st part. No. 51104.

The Steam Pumping Plant of the Charlottenburg Waterworks (Die Dampfpumpanlage für das Förderwerk der Charlottenburger Wasserwerk). E. Alberts. Illustrated description of compound horizontal pumping engines, with data and results of tests. 2000 w. 1 plate. Zeitschr d Ver Deutscher Ing—Sept. 20, 1902. No. 51313 D.

MACHINE WORKS AND FOUNDRIES.

Beam Bending.

Beam Bending Machine. E. C. Thulin. An illustrated description of a machine used in the construction of small cars, but applicable to other uses. 700 w. Am Mach—Oct. 23, 1902. No. 51274.

Brazing.

Brazing Cast Iron by a New Process. Illustrated description of this cast-iron brazing process patented by Friedrich Pich. 1000 w. Eng News—Oct. 16, 1902. No. 51219.

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Calipers.

Evolution of the Spring Caliper. E. R. Markham. Brief review of the improvements made and the growth of the business. Ill. 1100 w. Am Mach—Oct. 2, 1902. No. 50900.

Castings.

Casting Car Journal Bearings. C. Vickers. Detailed description of manner of casting car brasses. 1500 w. Am Mach—Oct. 2, 1902. No. 50901.

Cranes.

Anchors for Crane Chains—Casting Hoisting Drums. G. E. Flanagan. Illustrates the right and wrong methods and explains the advantages of methods recommended. 1400 w. Am Mach—Oct. 23, 1902. No. 51276.

Cupolas.

Chemistry and Cupola Practice. Edward Kirk. On the importance of properly understanding melting, and the troubles due to improper melting. 900 w. Foundry—Oct., 1902. No. 50870.

Designing.

Careless Designing. Peter H. Bullock. Remarks on mistakes in designing. 800 w. Am Mach—Oct. 2, 1902. No. 50899.

Drawing Room.

The Lodge & Shipley Drawing Room. Illustrated description of a well arranged office having features of interest. 1500 w. Mach, N Y—Oct., 1902. No. 50865.

Electric Driving.

See Electrical Engineering, Power Applications.

Foundry.

The New Westinghouse Foundry at Trafford City, Pa. Illustrated description of an industrial town near Pittsburg, and of the buildings erected for a large foundry. 1500 w. Eng Rec—Oct. 4, 1902. No. 50947.

Grinding.

Collection and Removal of Refuse from Grinding and Polishing Machines. A. W. Bayard. Discusses the reasons why such refuse should be removed and the most effective mode of accomplishing the desired end. 1500 w. Ir Trd Rev—Oct. 9, 1902. No. 51037.

The Norton Grinding Machine. Illustrated description of a machine made in Worcester, Mass., with report of the work done by it, its operation, time performance, etc. 3500 w. Engng—Oct. 17, 1902. No. 51422 A.

Indexing.

Fractional Indexing. C. E. De Puy. Gives an index table and an explanation of the writer's method. 1200 w. Am Mach—Oct. 23, 1902. No. 51275.

Keys.

Strength and Proportion of Keys. Frank P. Kleinhans. Gives method of calculating. 800 w. Am Mach—Oct. 9, 1902. No. 51041.

Ladles.

Slag and Metal Ladles. Illustrates and describes various recent types. 3000 w. Ir & Coal Trds Rev—Oct. 3, 1902. Serial. 1st part. No. 51085 A.

Lubrication.

Something About Oil Grooves. Charles J. Mason. Describes a system efficient in all particulars, and considers the supply of oil to the journals and bearings of a horizontal shaft. Ill. 2200 w. Engr, U S A—Oct. 1, 1902. Serial. 1st part. No. 50912.

Machine Tools.

Machine Tool Progress. Charles E. Hadley. The first of a series of illustrated articles dealing with this subject, and briefly reviewing the history of standard tools. 1500 w. Elec Rev, N Y—Oct. 25, 1902. Serial. 1st part. No. 51273.

Patterns.

The Difference Between Good and Bad Pattern Work. Gives the qualifications of a good pattern maker, and notes some of the failures of a poor one. Ill. 1500 w. Am Mach—Oct. 2, 1902. No. 50898.

Pipes.

Molding Pipes Without Patterns. Francis W. Shaw. Explains in detail a method which enables molding operations to be commenced immediately. Ill. 900 w. Am Mach—Oct. 2, 1902. No. 50897.

Shops.

Early Machine Shops and Mechanics. Historical notes on the development of the machine shop during the early part of the nineteenth century. Ill. 4800 w. Mach, N Y—Oct., 1902. No. 50866.

Shop Construction. Oscar E. Perrigo. The first of a series of illustrated articles upon the design and construction of machine shops, with hints upon the arrangement of tools, and the management. 2200 w. Mach, N Y—Oct., 1902. Serial. 1st part. No. 50864.

Wastes.

Workshop Wastes—Metals. W. J. May. Some suggestions for utilizing the metal of the scrap heap. 1200 w. Prac Engr—Oct. 3, 1902. No. 51060 A.

MATERIALS OF CONSTRUCTION.

Alloys.

See Electrical Engineering, Electro-Physics.

Balata.

Balata and Its Employment. Editorial on this material, which is so generally

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confused with gutta percha and rubber that statistics are not reliable. 2000 w. Engng—Oct. 17, 1902. No. 51425 A.

Elasticity.

The Laws of Elastic Extension (Zur Gesetzmässigkeit der Elastichen Dehnungen). W. Schüle. A review of recent experimental results, with curves of tests and comparisons between computed and experimental values. 2000 w. Zeitschr d Ver Deutscher Ing—Oct. 4, 1902. No. 51317 D.

Expansion.

The Expansion of Iron, Copper, Aluminum, Brass, and Bronze at High Temperatures (Ueber die Ausdehnung von Eisen, Kupfer, Aluminum, Messing, und Bronze in Hoher Temperatur). W. Dittenberger. Results of recent determinations of expansion coefficients made at the Reichsanstalt at Berlin. 2500 w. Zeitschr d Ver Deutscher Ing—Oct. 11, 1902. No. 51320 D.

Pig Iron.

Buying Pig Iron and Coke. W. G. Scott. Discusses the proper method of buying, and gives the J. J. Case Threshing Machine Co.'s specifications for foundry pig iron and for coke. 4200 w. Foundry —Oct., 1902. No. 50869.

Resistance.

The Conditions of Elasticity and Resistance of Various Kinds of Iron (Die Elastizitäts- und Festigkeitseigenschaften der Eisensorten). C. Bach. A study of the relation of elasticity and resistance of materials to temperature, with tables and diagrams of experimental results. 2000 w. 2 plates. Zeitschr d Ver Deutscher Ing—Oct. 11, 1902. No. 51321 D.

Structure.

The Internal Structure of Iron and Steel with Special Reference to Defective Material. S. A. Houghton. Shows that chemical analysis is not all that is needed in determining the quality of metals, and that an examination of the structure is of great importance. Considers the causes of failure, etc. Ill. 8300 w. Metallographist—Oct., 1902. No. 51124 F.

MEASUREMENT.

Calorimetry.

The Calorific Power of Coals (Sur le Pouvoir Calorifique de la Houille). M. Goutal. Giving a simplified formula for computing the calorific power of a given coal from its chemical composition. 700 w. Comptes Rendus—Sept. 22, 1902. No. 51376 D.

Indicator.

Pressure Indicator. Illustrates and describes the interesting features of an instrument invented by J. E. Petavel, with records showing how it works. 1300 w. Engr, Lond—Oct. 10, 1902. No. 51175 A.

Tanks.

The Content and Surface of Tanks (Inhalte und Oberflächen von Gefässen). M. Grellert. Discussing the method of computing tanks of various forms so that the surface may be a minimum and the content a maximum. 2500 w. Gesundheits-Ingenieur—Sept. 15, 1902. No. 51371 B.

POWER AND TRANSMISSION.

Compressed Air.

A King-Riedler Air Compressor of 1,000 Horse-Power. Illustrated detailed description. 1200 w. Am Mach—Oct. 16, 1902. No. 51214.

The Daw Air-Compressor. Illustrates and describes these machines and their operation. The object of the invention is the economical production at speeds hitherto thought unattainable, securing greater output from smaller machines. 2400 w. Engng—Sept. 26, 1902. No. 50969 A.

Conveying Machinery.

Crushing, Preparing, and Conveying Machinery (Müllerei, Hartzerkleinerung, und Mechanische Aufbereitung nebst Transport und Umladevorrichtungen). H. Rasch. Reviewing especially the devices shown at the Düsseldorf exposition. Serial. Part I. 2000 w. Zeitschr d Ver Deutscher Ing—Oct. 11, 1902. No. 51319 D.

See Gas Works Engineering.

Elevators.

A High Drop Test of an Elevator Safety Air Cushion. An account of an interesting test made in the Philadelphia City Hall tower. The passenger elevator, weighing 2,500 lbs., was allowed to drop from the top of the shaft, a free fall of 290 feet before entering the air cushion. 2000 w. Eng News—Oct. 9, 1902. No. 51098.

Shafting.

The Capacity of Shafting. A. G. Holman. Gives a graphic representation of the usual formula for horse-power laid out on a logarithmic scale, with rules for its use. 600 w. Power—Oct., 1902. No. 50878 C.

Telpherage.

See Electrical Engineering, Power Applications.

SPECIAL MOTORS.

Alcohol.

Alcohol Power Generating Set (Groupe Electrogène à l'Alcool). MM. Sartiaux & Cossman. Describing the convenient arrangement of alcohol motor and dynamo used for charging accumulators for

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operating winches at the small stations of the Northern Railway of France. 2000 w. Rev Gen des Chem de Fer—Sept., 1902. No. 51377 H.

Binary Engines.

The Binary Steam Engine (Die Abwärme-Dampfmaschine). H. Behrend. A discussion of the thermodynamic principles involved in the design of binary vapor engines with curves of specific volumes of various substances available for use in the second cylinder. 1500 w. Zeitschr d Ver Deutscher Ing—Oct. 4, 1902. No. 51318 D.

Diesel Motor.

The Diesel Oil Engine. Arnold G. Hansard. Illustrates and describes the principal characteristics of this engine and discusses the cost of working. 1500 w. Elec Times—Oct. 16, 1902. Serial. 1st part. No. 51298 A.

The New Diesel Oil Engine. An illustrated description of the improved engine which is capable of consuming petroleum refuse, so that it may be operated on the crudest of oils. 2300 w. Am Elect'n—Oct., 1902. No. 51026.

Gas Engines.

A Preliminary Note on Gas-Engine Explosions. H. E. Wimperis. Read before the British Assn. An application of the variable specific heat hypothesis to the classical experiments made by Mr. Dugald Clerk. An important contribution to the thermodynamics of heat engines, and of interest to designers of gas engines. 1100 w. Engng—Oct. 10, 1902. No. 51172 A.

Avoiding Trouble with a Gas Engine. H. H. Kelley. On the care and attention needed. 1600 w. Engr, U S A—Oct. 1, 1902. No. 50914.

Design of Gas Engines. James Dunlop. The first of a series of articles on the operation of gas engines, and the design of the various parts. 1400 w. Mech Engr—Oct. 4, 1902. Serial. 1st part. No. 51071 A.

500 H.-P. Double-Acting Körting Gas Engine and Blowing Cylinder. Illustrated description of an engine exhibited at Düsseldorf. 350 w. Plate. Engng—Sept. 26, 1902. No. 50970 A.

Gas Engines for High-Pressure Fire Service. J. R. Bibbins. A short description of the engines to be installed in the city of Philadelphia, the principal reasons for their adoption and their inherent qualifications for the required duty. Ill. 3500 w. Ins Engng—Sept., 1902. No. 50919 C.

Power Gas and Producer Gas Installations Working with Pressure and with Exhaust. Summary of a paper by Herr Johann Korting, published in the *Journal für Gasbeleuchtung*. Reviews the work of investigators leading to the use of producer gas, and describes a plant dispensing with the steam boiler. 1800 w. Gas Wld—Sept. 27, 1902. No. 50955 A.

The Commercial Development of the Gas Engine. Reviews the work of the early inventors and progress to the present, beginning an illustrated description of the Westinghouse engine. 4000 w. Mech Engr—Oct. 11, 1902. Serial. 1st part. No. 51158 A.

The Determination of Fuel Consumption in Gas Engines (Evaluation de la Consommation dans les Moteurs à Gaz). J. Deschamps. A discussion of the varying methods of recording the performance of gas engines, with suggestions as to the unifying of methods in order to render results comparable. 5000 w. Mem Soc Ing Civ de France—Aug., 1902. No. 51328 G.

The New Niel Motor (Le Nouveau Moteur Niel). A. Moreau. A fully detailed description of the improved gas engine of the Niel Company, with data and results of tests showing more than 25 per cent. thermal efficiency. 8000 w. 2 plates. Mem Soc Ing Civ de France—Aug., 1902. No. 51330 G.

Gasoline Engines.

Loss of Power in Gasoline Engines. Albert Stritmatter. Considers causes of decrease in power, and the remedies. 2000 w. Am Mfr—Oct. 9, 1902. No. 51105.

Gas Power.

Gas Power Station for an Electric Hoisting Machine (Gas-Kraft Primäranlage für eine elektrische Fördermaschine). Illustrating a combined generating set of 100 h. p. gas engine and dynamo in connection with a Pintsch gas producer for driving an electric mine hoist. 1200 w. Glückauf—Oct. 11, 1902. No. 51350 B.

The Pintsch Power Gas Plant. Illustrates and describes a gas plant supplying two 80-h. p. Otto cycle engines in which no gas-holder is employed. 1800 w. Ir & Coal Trds Rev—Oct. 17. 1902. No. 51426 A.

Internal Combustion.

Progress in Internal Combustion Engines. W. H. Booth. A review of recent advances in economy, reliability and range of adaptation, showing the advantages of high compression and the progress in the utilization of waste furnace gases. 3000 w. Engineering Magazine—November, 1902. No. 51395 B.

STEAM ENGINEERING.

Binary Engines.

See Mechanical Engineering. Special Motors.

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Boilers.

Boilers: Old and New. Louis F. Pearson. Read before the Inst. of Heat. & Ven. Engrs. (England). Deals with hot water boilers only, giving illustrations of English boilers and discussing their merits. Also general discussion. 5000 w. Plumb & Dec—Oct. 1, 1902. No. 51070 A.

Riveted Joints for Steam Boilers. W. H. Wakeman. States facts showing the only safe way is to determine the strength of every joint, and endeavors to give plain rules for doing this. 1600 w. Elec., N Y—Oct. 29, 1902. Serial. 1st part. No. 51288.

Steam Boiler Settings and Appurtenances. C. F. Swingle. The present article considers walls and furnaces, fittings and safety appliances, domes and mud drums, feed pipes, etc. Ill. 3500 w. Steam Engng—Oct. 10, 1902. Serial. 1st part. No. 51270.

The Solignac Boiler. W. H. Booth. Read at Belfast meeting of the Brit. Assn. An account of tests made of this water-tube boiler, with description of its important features. 2900 w. Mech Engr,—Oct. 4, 1902. No. 51072 A.

Calorimetry.

See Mechanical Engineering, Measurement.

Condensers.

Surface Condensers. C. G. Robbins. Discusses the formulas of J. M. Whitham and C. P. Poole, and illustrates their application by an example. 1800 w. Marine Engng—Oct., 1902. No. 51008 C.

The Cooling of Condensing Water. Gives results of experience and observation in respect to the cooling of injection water for condensing and other purposes, indicating points that should be considered. 1500 w. Prac Engr—Sept. 26, 1902. No. 50954 A.

Water Cooling Appliances for Condensers (Kühlwasserakkumulator für Kondensatoren). F. J. Weiss. A review of the various methods of cooling condenser water for repeated use. Serial. Part I. 3500 w. Zeitschr d Ver Deutscher Ing—Sept. 27, 1902. No. 51314 D.

Condenser Tubes.

Condenser Tube Electrolysis and Corrosion. James F. Hobart. An explanation of what takes place and suggestions of remedies. Ill. 2500 w. Power—Nov., 1902. No. 51299 C.

Corrosion.

Corrosion of Boilers by Magnesium Chloride. Editorial review of a paper by H. Ost in the *Chemiker Zeitung*, giving an account of experimental investigations. 900 w. Engng—Oct. 10, 1902. No. 51171 A.

Dusseldorf.

Steam Engines at the Düsseldorf Exposition (Les Machines à Vapeur à l'Exposition de Düsseldorf). P. Dujardin. A general review of the engines exhibited at Düsseldorf, with tabular view of the whole. 2500 w. 1 plate. Génie Civil—Sept. 20, 1902. No. 51302 D.

Feed-Water.

Comparative Methods of Heating Feed Water. Presents the heat balances and cost figures for six of the systems in common use, arranged for comparison. 3500 w. Power—Nov., 1902. No. 51401 C.

Feed Waters and Their Action on Boilers. Clifford A. Bowen. Considers the impurities contained in water and their effect on boiler plates; the methods of purification, tests, etc. 4000 w. Elec Rev, Lond.—Oct. 3 and 17, 1902. Serial. 2 parts. No. 51402 each A.

Firing.

See Marine Engineering.

Flywheels.

Safe Speeds for Flywheels. William H. Boehm. From the *Monthly Bulletin* of the Fidelity and Casualty Co. Gives solution of the problem of finding the speed at which disruption will occur. 1200 w. Eng News—Oct. 2, 1902. No. 50921.

Fuel.

The Relative Values of Fuel. Gives the results of Prof. William Kent's experiments, as given in "Steam Boiler Economy." Also results obtained by other experimenters, with remarks. 1300 w. Dom Engng—Oct. 25, 1902. No. 51260 C.

Generating Sets.

See Electrical Engineering, Generating Stations.

Lubrication.

Oil Systems. H. D. Drew. Illustrates and describes a gravity system installed in a large power plant. 1700 w. Power—Nov., 1902. No. 51400 C.

The Use of Low Grade Oil and its Effect upon the Air Discharged from a Condenser. R. S. Carter. States an experience in tunnel work which caused the air to become so impure as to affect the workers, which was traced to the use of poor oil. 600 w. Compressed Air—Oct., 1902. No. 51231.

Oil Fuel.

Oil Burning. Frank H. Bates. Reviews the Billow system of oil burning. The present paper illustrates and describes the methods and apparatus used for the preparation and delivery of oil to the burners. 900 w. Jour of Elec—Oct., 1902. Serial. 1st part. No. 51192 C.

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Pipes.

Steam Pipe Sizes. Charles L. Hubbard. Gives methods of computing pipe sizes to meet the usual requirements in low and high pressure work. 2500 w. Engr, U. S. A.—Oct. 15, 1902. No. 51228.

Piston Valves.

Some Notes on Piston Valves. F. A. Haughton. Calls attention to peculiarities inherent in certain types. Diagrams and indicator cards with general discussion. 4200 w. Pro Richmond Ry Club—Sept. 11, 1902. No. 50918.

Power Plants.

The Designing of Steam Power Plants. Walter C. Kerr. Aims to point out some of the ways and means by which the engineer may deal first with the general and then with the specific questions involved, and to indicate something of the service that may be expected of the engineer in making determinations underlying large expenditures. 3000 w. St Ry Jour—Oct. 4, 1902. No. 50985 D.

Prime Movers.

Prime Movers and Their Ailments. Editorial review of the report of Mr. Michael Longridge of failures and accidents and their causes. 2000 w. Engng—Oct. 17, 1902. No. 51424 A.

Rotary Engines.

A Novel Rotary Engine. Illustrates and describes a rotary steam engine patented by Oliver C. Jones. 900 w. Sci Am—Oct. 25, 1902. No. 51293.

The Hult Rotary Steam Engine. An illustrated description of the construction and method of working. 2000 w. Engng—Oct. 17, 1902. No. 51423 A.

Scale.

Boiler Scale and the Transmission of Heat. Showing that scale of ordinary thickness is objectionable because it raises the temperature of the boiler plate, rather than because it cuts down the efficiency of the boiler. 3000 w. Locomotive—Sept., 1902. No. 51143.

Smoke.

Smoke Abolition. T. T. Parker. Discusses points in a recent article by W. H. Booth, and suggests inexpensive changes that give good results in small plants. Ill. 1500 w. Am Mach—Oct. 16, 1902. No. 51215.

Smoke and Its Abatement in Large Cities. C. H. Benjamin. Considers the nature of soft coal smoke and the devices which cause complete combustion and so prevent smoke. Ill. 1800 w. Tech Or—Sept., 1902. No. 51127 E.

The Prevention of Smoke. John S. Raworth. Abstract of a paper read at Belfast meeting of the Brit. Assn. Concerning the Wilson process, which consists in squirting a mixture of air and nitrate of soda solution on the fire. Also report of a series of tests. 1400 w. Elect'n, Lond—Sept. 26, 1902. No. 50963 A.

The Prevention of the Smoke Nuisance and Waste of Fuel (Rauchplage und Breunstoffverschwendung und deren Verhütung). A study of the chemical reactions involved in the smokeless combustion of fuel, discussing the practicability of its successful accomplishment. 3000 w. Gesundheits-Ingenieur—Sept. 30, 1902. No. 51372 B.

The Smokeless Combustion of Bituminous Fuels. W. H. Booth. Read at Belfast meeting of the Brit. Assn. A study of the conditions required for smokeless combustion. 2700 w. Elec Rev, Lond.—Sept. 26, 1902. No. 50961 A.

The Suppression of Smoke in Steam Plants Using Bituminous Coal. Albert A. Cary. Discusses the theory of smoke suppression, various methods of firing and furnace developments, and gives short descriptions of some special hand fired furnaces designed to suppress smoke and promote fuel economy. 4000 w. Ir Age—Oct. 2, 1902. Serial. 1st part. No. 50861.

Speed Regulation.

Governors and Governing Mechanism. Herbert Reed Hall. Describes various forms of governors and considers the essential qualities that a governor should possess. 1800 w. Prac Engr—Oct. 3, 1902. Serial. 1st part. No. 51059 A.

Hand Adjustment of the Governors of Steam Plants in Electric Light Stations. J. H. Dales. Explains what is meant by hand adjustment, considering only high-speed, spring-load centrifugal governors in studying the limit of possibilities. 1500 w. Elect'n, Lond—Oct. 3, 1902. No. 51078 A.

Relays and Governors. Arthur Rigg. A discussion of the action and performance of various regulating appliances for steam engines, giving descriptions of arrangements and combinations, with critical comments. Ill. 3500 w. Engr, Lond—Oct. 17, 1902. No. 51420 A.

Steam Heating.

Low-Pressure Steam Heating with Open Air Pipes. S. Naylor. Read before the Iinst. of Heat. & Ven. Engrs. (England). States the advantages of this system and gives an illustrated description. Also discussion. 4200 w. Plumb & Dec—Oct. 1, 1902. No. 51069 A.

Methods of Heating the Basement. H. H. Kelley. Illustrates and describes arrangement for heating by hot water, and also by steam. 1500 w. Engr, U S A—Oct. 15, 1902. No. 51229.

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Steaming Capacity.

The Relation Between Heating Surface and Cylinder Power. Lawford H. Fry. Gives a measure for the steaming capacity of locomotives. 2000 w. Am Engr & R R Jour—Oct., 1902. No. 50-894 C.

Steam Mains.

Cast vs. Wrought Iron Steam Mains. C. G. Robbins. Favoring cast mains, discussing the objections urged against them, and considering other methods of constructing steam mains. Ill. 3800 w. Power—Oct., 1902. No. 50879 C.

Steam Turbines.

The Steam Turbine. Its Commercial Aspect. Edward H. Sniffin. Read before the St. Ry. Assn. An inquiry into its commercial utility, giving detailed information of plants now in operation, discussing their cost, and the cost of operation as compared with steam plants. 5800 w. St Ry Rev—Oct. 11, 1902. No. 51-188 C.

The Westinghouse Steam Turbine. Edwin Yawger. Read before the Ohio Elec. Lgt. Assn. An illustrated description of mechanical details of the machine and of its action. 1900 w. Am Mfr—Oct. 23, 1902. No. 51256.

Westinghouse Steam Turbines for the Rapid Transit Subway. Illustrated description of the installation for use in connection with the lighting of the subway. 1800 w. Power—Oct., 1902. No. 50880 C.

Superheating.

Engines for Use with Superheated Steam (Stoommachines met Hoog-Overhittenstoom). C. F. Stork. A review of the question of superheated steam, with data and results from a number of engines in use in the Netherlands. 3500 w. Ingenieur—Oct. 11, 1902. No. 51368 D.

See Railway Engineering, Motive Power.

Thermodynamics.

The "Series-Vapor" and "Heat Waste" Engines, as Supplementary to Single-Vapor Engines. R. H. Thurston. A study of the problem of how to secure the largest amount of energy with the least waste. 7000 w. Jour Fr Inst—Oct., 1902. Serial. 1st part. No. 50868 D.

Valve Gears.

Positive and Releasing Valve Gears for Hoisting Engines (Freifall oder Zwangschleiss bei Fördermaschinen Ventilsteuerungen?) A. Ehrlich. A comparison between the reliability of trip valve gears and positively actuated valves. 1200 w. Glückauf—Sept. 27, 1902. No. 51348 B.

Some Special Problems in Valve-Gear Design by the Zeuner Diagram. Walter C. Kretz. Gives a mathematical demonstration of the problem—"Given the crank angle at cut-off, the lead, and the maximum port-opening, to find the minimum travel to suit these conditions." Also demonstrates other propositions required in the proof. 7800 w. Sch of Mines Qr—July, 1902. No. 51128 D.

The History of the Walschaert Valve-Gear. Translation of an article by M. J. Boulvin in the *Revue de Mecanique*, relating the circumstances under which Walschaert brought forth his invention. 1800 w. R R Gaz—Oct. 24, 1902. No. 51278.

MISCELLANY.

Alcohol.

Lighting and Heating Apparatus (Appareils d'Eclairage et de Chauffage). G. Arachequesne. An illustrated review of the devices for utilizing alcohol in incandescent burners, and in heating appliances. 7000 w. Mem Soc Ing Civ de France—Aug., 1902. No. 51326 G.

International Alcohol Exposition of Lighting and Heating Apparatus. Translated from *La Nature*. Illustrates and describes apparatus for using alcohol as a means of heating and lighting. 1500 w. Sci Am Sup—Oct. 25, 1902. No. 51297.

Aluminothermy.

The Applications of Aluminothermy (L'Alumino-thermie et ses Applications). H. Bertin. A general account of the Goldschmidt process for producing high temperatures by the combustion of aluminum, and a discussion of its practical applications. 7000 w. Mem Soc Ing Civ de France—Aug., 1902. No. 51329 G.

Artillery.

Artillery at the Düsseldorf Exposition 1902 (Geschütze auf der Düsseldorfer Ausstellung 1902). J. Castner. A fully illustrated review of the artillery exhibits at Düsseldorf, with especial reference to the mechanical and engineering problems involved. Two articles. 5000 w. Stahl u Eisen—Oct. 1, 15, 1902. No. 51335 each D.

Düsseldorf Exposition.

Machinery Department of the Düsseldorf Exposition. H. L. Terwilliger. A review of the interesting exhibits, especially those using compressed air. 1600 w. Compressed Air—Oct., 1902. No. 51232.

Refrigeration.

Refrigeration on Shipboard. E. N. Percy. Points out some errors in refrigerating equipment on vessels, discussing points in design of apparatus, and the plan and operation of cold rooms. 4000 w. Ice & Refrig—Oct., 1902. No. 50-889 C.

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MINING AND METALLURGY

COAL AND COKE.

Accidents.

Fatal Accidents in Coal Mines in North America, 1901. Frederick L. Hoffman. Tabulated information with remarks. 900 w. Eng & Min Jour—Oct. 25, 1902. No. 51237.

Briquettes.

German Processes and Machinery for Briquette Manufacture. An account of this industry in Germany, the machines used, etc. Ill. 2500 w. U S Cons Repts, No. 1466—Oct. 11, 1902. No. 51048 D.

By-Product Coke.

By-Product Oven Coke Making in 1901. Edward W. Parker. From the Mineral Resources of the United States report on the Manufacture of Coke. 1800 w. Pro Age—Oct. 1, 1902. No. 50862.

Charcoal.

Charcoal Burning in the Lake District. Details of the business as carried on in the Furness district of Lancashire, England. 2200 w. Engng—Sept. 26, 1902. No. 50971 A.

Coal-Fields.

The Cumberland Plateau Coal-Field. M. S. Duffield. Explains why this valuable field in Tennessee and Kentucky has not been developed, and describes the occurrence of the coal veins and the preparations for working. Ill. 2000 w. Eng & Min Jour—Oct. 4, 1902. No. 51015.

The Identity of the Newcastle and Cumberland Coalfields. David Burns. Abstracts of a paper and its discussion before the N. of England Inst. of Min. & Mech. Engrs. Aiming to show they are two parts of the same field. 2000 w. Col Guard—Sept. 26, 1902. No. 50965 A.

Coal Seams.

On the Probability of Finding Workable Seams of Coal in the Carboniferous Limestone or Bernician Formation Beneath the Regular Coal Measures of Northumberland and Durham, with an Account of a Recent Boring Made in Chopwell Woods. J. B. Simpson. Read before the N. of England Inst. of Min. & Mech. Engrs. Abstracts of paper and discussion. 4000 w. Col Guard—Sept. 26, 1902. No. 50964 A.

Coal Strike.

See Industrial Economics.

Coal Substitutes.

Substitutes for Coal in Heating and Cooking. An illustrated discussion of the relative merits of other fuels, and the appliances used in burning them. 2200 w. Sci Am—Oct. 25, 1902. No. 51292.

Coal Trade.

See Industrial Economics.

Dust.

The Evils of Coal, Ganister and Slag Dust. Review of an address by Sir James Crichton Browne on the hygiene of certain occupations. 1000 w. Col Guard—Oct. 3, 1902. No. 51087 A.

Explosions.

Damping the Air of Coal Mines as a Safeguard Against Explosions. James Ashworth. Gives the recommendations of the Royal Commission, and discusses how far they have been carried out, and the results. Concludes that no means have yet been devised that protects with any degree of certainty. 3800 w. Ir & Coal Trds Rev—Sept. 26, 1902. No. 50973 A.

Firedamp.

When is Firedamp Dangerous in a Coal Mine? A discussion of this subject as presented in the inquiry into the McLaren Colliery disaster. 2000 w. Col Guard—Oct. 10, 1902. No. 51167 A.

France.

The Coal Mines of Northern France (Notizen über Steinkohlen Bergwerke in Nord-Frankreich). H. Stein. A general description of the Pas de Calais and Nord districts, with maps and details of installations. 6000 w. 3 plates. Glückauf—Sept. 20, 1902. No. 51347 B.

Kansas.

The Kansas Coal Mines of the Missouri Valley. W. R. Crane. A short description of the typical mines of this district. 4000 w. Eng & Min Jour—Oct. 18, 1902. No. 51208.

Mine Fires.

Fires in Coal Mines (Etude sur les Feux des Mines de Houille). J. Abadie. A study of the origin of fires in coal mines, and the most effective methods of controlling them, based upon experience in the Decazeville district, in the department of Aveyron, France. Serial. Part I. 2000 w. Génie Civil—Oct. 4, 1902. No. 51305 D.

Peat.

The Electrical Manufacture of Peat Fuel. Illustrates and describes a new process of carbonizing peat, invented by P. Jebsen, of Norway. 1500 w. Sci Am—Oct. 11, 1902. No. 51051.

The Utilization of the Peat Fuels of

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Europe. Adolf Dal. A review of the application of mechanical devices to the cutting and milling of peat for its adaptation to power-plant service. 3500 w. Engineering Magazine—November, 1902. No. 51394 B.

Philippines.

Coal Beds of Cebu and Masbate: Processes of Getting the Product. Illustrates and gives information concerning these deposits in the Philippine Islands and past methods of working. 1000 w. Am Gas Lgt Jour—Oct 6, 1902. No. 50998.

South Wales.

The Re-Survey of the South Wales Coal Measures. An account of the re-examination of this field, giving a report of some of the work of the past year. 2800 w. Ir & Coal Trds Rev—Oct. 3, 1902. No. 51086 A.

Storage.

Coal Storage. Waldon Fawcett. Brief review of methods commonly employed for storing anthracite coal, with illustrations. 1200 w. Sci Am—Oct. 18, 1902. No. 51201.

Tasmania.

The Coal Resources of Tasmania. Hartwell Conder. An account of the varieties of coal found, the geology of the island, etc. 2200 w. Aust Min Stand—Aug. 28, 1902. No. 50162 B.

COPPER.

California Mine.

The Greenback Copper Mine, Kern County, California. H. W. Turner. A description of this lode. 1100 w. Eng & Min Jour—Oct. 25, 1902. No. 51239.

Copper.

See Electrical Engineering, Electrochemistry.

Ducktown.

The Ducktown Copper Mining District. S. W. McCallie. An illustrated article describing the location of this deposit in Tennessee and Georgia, and giving an account of its discovery and operation. 1700 w. Eng & Min Jour—Oct. 4, 1902. No. 51014.

Smelting.

Reverbatory Copper Smelting. L. J. Charles. Gives a synopsis of the reverberatory method and discusses details. 900 w. Min Rept—Oct. 23, 1902. Serial. 1st part. No. 51287.

GOLD AND SILVER.

Alluvial Mining.

Alluvial Gold-Mining Appliances. An illustrated description of machines and accessories which have proved to be of special importance in alluvial gold-mining on the Clermont field. 3500 w. Queensland Gov Min Jour—Aug. 15, 1902. Serial. 1st part. No. 50887 B.

Concentration.

Mexican Plannillas. Ernest E. Payne. Illustrates and describes a primitive method of concentration which has been in use in Mexico since ancient times. 1000 w. Mines & Min—Oct., 1902. No. 51046 C.

The Silver King Concentrating Mill, Park City, Utah. James H. Steele. Describes the process of concentration of the lower grade ores as carried out at this mill, which has a capacity of about 100 tons in ten hours, and at present is running 19 hours out of every 24. Ill. 1600 w. Min & Sci Pr—Oct. 11, 1902. No. 51181.

Dutch East Indies.

The Mining and Occurrence of Gold in the Dutch East Indies. S. J. Truscott. Abstract of a paper read before the Inst. of Min & Met., London. The present article gives an account of what has been done toward developing the mines of Sumatra and Borneo. Map. 2900 w. Eng & Min Jour—Oct. 4, 1902. Serial. 1st part. No. 51016.

Extraction.

Extraction from Low Grade Ores. Begins a description of the Schilz process for the extraction of gold. 1500 w. Aust Min Stand—Aug. 21, 1902. Serial. 1st part. No. 50951 B.

Goldfield.

The Clermont Goldfield. A report by B. Dunstan, assistant government geologist. Describes the geological considerations, the alluvial deposits, etc., of this district in Queensland. 11500 w. Queensland Gov Min Jour—Aug. 15, 1902. Serial. 1st part. No. 50888 B.

Nome.

Gold Mining in the Nome District. Lewis Garrison. An account of the companies formed, and the need of water, showing that the district has passed largely into the hands of companies with large capital. 1200 w. Eng & Min Jour—Oct. 4, 1902. No. 51017.

Ore Treatment.

Improvements in the Treatment of Gold Ores (Neuerungen in der Behandlung von Golderzen). Hermann Pape. With especial reference to the preparation of gold ores for treatment by the cyanide process. 5000 w. Zeitschr d Ver Deutscher Ing—Sept. 27, 1902. No. 51316 D.

Slimes.

The Smelting and Refining of Zinc Gold Slimes. E. H. Johnson and W. A. Caldecott. A discussion of methods and results. 3400 w. Jour of Chem & Met

We supply copies of these articles. See page 493.

Soc of S. Africa—July, 1902. No. 50-846 E.

Smelting.

The New Smelter Plant at Crofton. W. M. Brewer. Illustrated description of this plant, on the east coast of Vancouver Is. 1500 w. B C Min Rec—Oct., 1902. No. 51120 B.

Stamp Mills.

Stamp Mill Construction. J. J. Deming. Condensed from a paper read before the Mining Congress. On the need of adapting mills to the requirements of the ore to be treated, considering important factors. 4000 w. Min & Sci Pr—Oct. 4, 1902. No. 51039.

Treatment.

Mexican Methods of Silver Ore Treatment. J. Nelson Nevins. An illustrated description of the patio process, developed in the middle of the sixteenth century. 800 w. Eng & Min Jour—Oct. 18, 1902. No. 51207.

IRON AND STEEL.

Billet Mill.

New Billet Mill at Youngstown. Illustrations and details of the Republic Iron & Steel Co.'s new mill. 1000 w. Ir Trd Rev—Oct. 9, 1902. No. 51038.

Dusseldorf.

The Iron Manufacturing Industry (Das Eisenhüttenwesen). Fr. Frölich. An illustrated review of the exhibits at the Düsseldorf exposition relating to the iron and steel industries. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—Sept. 20, 1902. No. 51312 D.

The Metallurgy of Iron and Steel (La Metallurgie du Fer et de l'Acier). Alexandre Gouve. A very complete review of the exhibits at the Düsseldorf exposition relating to the manufacture of iron and steel and the allied industries. 20,000 w. 6 plates. Rev Univ des Mines—Aug., 1902. No. 51331 G.

Electric Driving.

See Electrical Engineering. Power Applications.

Germany.

Progress of German Steel and Rolling Mills since 1880 (Die Fortschritte in den Deutschen Stahl und Walzwerken seit 1880). R. M. Daelen. A brief review of German progress in steel making, showing especially the advance in the production of steel by the basic process. 2000 w. Stahl u Eisen—Sept. 15, 1902. No. 51333 D.

The Development of Pig Iron Manufacture in Germany since 1880 (Die Fortschritte in der Roheisenerzeugung Deutschlands seit 1880). W. Brügmann. Giving diagrams showing the enormous progress made in the past 20 years. Two articles. 7500 w. Stahl u Eisen—Sept. 15, Oct. 1, 1902. No. 51332 each D.

The Iron Industry in Germany from a Technical Point of View. W. Brugmann. Read at the Düsseldorf meeting of the Ir. & Steel Inst. Remarks on the progress in the manufacture of coke, and discussion of details in German blast furnaces. 2800 w. Ir Trd Rev—Oct. 23, 1902. No. 51-262.

Hot Blast.

Results Obtained in Equalizing the Temperature of Hot Blast. Lawrence F. Gjers and Joseph H. Harrison. Read at Düsseldorf meeting of the Iron & Steel Inst. Illustrated description of an equalizer with report of its work. 2000 w. Ir & Steel Trds Jour—Sept. 27, 1902. No. 50915 A.

Ingots.

Compressing Steel Ingots by Wire Drawing in the Ingot Mold. An illustrated description of apparatus as given in a paper by A. Harmet, read at Düsseldorf meeting of the Iron & Steel Inst. 2500 w. Eng News—Oct. 2, 1902. No. 50925.

Iron Ores.

The Mesaba Range. Reviews a report prepared by Charles K. Leith for the U. S. Geol. Surv., considering the origin and development of the ore deposits of this iron-bearing district. 4000 w. Ir Age—Oct. 23, 1902. No. 51213.

The Valuation of Iron Ores and Other Raw Materials (Die Bewerthung von Eisenerzen und anderen Schmelzstoffen). Bernhard Osann. A detailed examination of the elements involved in the valuation of the ore coke, flux and other materials used in the making of iron, based on their relative uses in the furnace. Two articles. 6000 w. Stahl u Eisen—Oct. 1, 15, 1902. No. 51334 each D.

Iron Works.

The Cette Iron Works (Les Haut Fourneaux et Forges de Cette). Ch. Dantin. An illustrated description of the new blast furnaces and forges of Messrs. Schneider & Co., at Cette; department of Hérault, France. 2500 w. 1 plate. Génie Civil—Oct. 11, 1902. No. 51306 D.

Sulphur.

Sulphide of Iron (Sulfure de Fer). MM. Le Chatelier & Ziegler. A study of the state in which sulphide of iron exists in cast iron, and the nature of its influence upon the metal. 7000 w. Bull Soc d'Encour—Sept. 30, 1902. No. 51-322 G.

Tin Plate.

The Manufacture of Tin Plate. An illustrated description of this industry as carried on at the Laughlin Works of the

American Tin Plate Co., at Martin's Ferry, Ohio. 1600 w. Sci Am—Oct. 4, 1902. Serial. 1st part. No. 50937.

Titanium.

The Metallurgy of Titanium. Auguste J. Rossi. A discussion of this class of iron ores, the objections against them, the experimental researches made, their value under proper treatment, results obtained, tests, etc. 7000 w. Jour Fr Inst—Oct., 1902. No. 50867 D.

MINING.

By-Products.

The Residual Products of the Dynamite Factory and Their Value to the Gold Industry. William Cullen. Aims to show that many of these by-products could be utilized in the mining industry. 3300 w. Jour Chem & Met Soc of S Africa—Aug., 1902. No. 50950 E.

Electric Power.

See Electrical Engineering, Power Applications.

Explosives.

Testing Mine Explosives. A. W. Warwick. Showing the difficulties and uncertainties in determining practical values of different explosives. 2000 w. Mines & Min—Oct., 1902. No. 51042 C.

Japan.

The Mining Industry of Japan. E. W. Nardin. The present article considers copper mining, this country standing third as a producer of this metal. Ill. 1700 w. Aust Min Stand—Sept. 4, 1902. Serial. 1st part. No. 51063 B.

Mine Locomotives.

Benzine Locomotives for Gaseous Mines (Benzinlocomotive für Schlagwettergruben). L. Volf. Describing a convenient form of mine locomotive operated by an Otto benzine motor for use in localities in which electric sparking might be dangerous. 2000 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Oct. 4, 1902. No. 51346 D.

Mining Plant.

Notes on Machinery Constituting a Mining Plant. Alfred C. Garde. Notes written with a particular view to conditions in British Columbia, but useful to mine investors and engineers in charge of any mining properties. 2000 w. Can Min Rev—Sept. 30, 1902. No. 51005 B.

Mining Railway.

The Underground Railway of the Stassfurt Salt Mines (Die Untergrundbahn des Königlichen Salz werkes zu Stassfurt). J. Westphal. Illustrating and describing the electric railway system recently installed in the Stassfurt salt mines. 4000 w. 3 plates. Glückauf—Oct. 4, 1902. No. 51349 B.

Power Distribution.

Distribution of Power in English Mines. Sydney F. Walker. Considers the use of ropes and chains and the causes of loss and waste of power. 2000 w. Mines & Min—Oct., 1902. No. 51047 C.

Shafts.

Shaft Sinking. C. K. Colvin. Points from the writer's experience on the subject of sinking and timbering perpendicular cage shafts for the working of metalliferous mines. 1800 w. Min & Sci Pr—Oct. 4, 1902. No. 51040.

Signalling.

Mine Signalling by Compressed Air. Bernard MacDonald and William Thompson. Discusses methods of signalling from the mine workings to the engineer running the hoisting engine. Describes the system in general use and illustrates and describes the compressed air signal system, stating its advantages. 3000 w. Can Min Rev—Sept. 30, 1902. No. 51003 B.

Surveying.

Shaft Surveying. T. Lane Carter. Deals with the practice in the Johannesburg gold-fields for surveying vertical shafts. 2000 w. Eng & Min Jour—Oct. 11, 1902. No. 51109.

Timbering.

Mine Timbering by the Square Set System at Rossland, B. C. Bernard MacDonald. Describes the vein characteristics at Rossland, and the methods of construction used. Ill. 5400 w. Can Min Rev—Sept. 30, 1902. No. 51002 B.

Vancouver Is.

Mineral Resources of Vancouver Island. W. M. Brewer. Read before the Can. Min. Inst. Gives a brief history of the coal mining and metal mining, geological formation, production, etc. 4500 w. Can Min Rev—Sept. 30, 1902. No. 51004 B.

Winding.

The Mexican Malacate. J. Nelson Nevins. Illustrated description of an apparatus used in Mexico for purposes of sinking, prospecting or ventilating shafts, or for development work. 900 w. Eng & Min Jour—Sept. 27, 1902. No. 50829.

MISCELLANY.

Alloys.

See Electrical Engineering, Electro-Physics.

Aluminum.

Aluminum as a Reducing and Heat Producing Agent. H. Hofman. Discusses the action of aluminum as a reducing agent, giving a review of the early applications, and also the more recent, especially of the Gold-chmidt process. 4000 w. Am Mfr—Sept. 25, 1902. No. 50827.

Borax.

Reconnaissance of the Borax Deposits of Death Valley and Mohave Desert. Marius R. Campbell. Describes these deposits, and their development. Ill. 2300 w. Eng & Min Jour—Oct. 18, 1902. No. 51209.

Calcium.

See Electrical Engineering, Electrochemistry.

Galena-Joplin.

Recent Changes in Mining and Milling in the Galena-Joplin Lead and Zinc District. W. R. Crane. Considers the methods of leasing and mining, milling, etc. Ill. 3200 w. Eng & Min Jour—Sept. 27, 1902. No. 50828.

Gypsum.

Recent Developments in the Gypsum Industry in New York State. From report of the N. Y. State Geologist, Arthur L. Parsons. Describes the quarries at Fayetteville and their working. 2500 w. Stone—July, 1902. No. 51140 C.

Lead.

On the Determination of Lead in Ores. Irving C. Bull. A comparison of the best existing methods in order to select a method which may be recommended both because of its accuracy and rapidity. 4300 w. Sch of Mines Qr—July, 1902. No. 51129 D.

See Electrical Engineering, Electrochemistry.

Petroleum.

Notes and Methods on the Determination of Water, Sand, etc., in Crude Petroleum of Low Gravity. P. W. Tompkins. Read before the Pacific Coast Gas Assn. Describes methods tried on California oils. 4000 w. Am Gas Lgt Jour—Sept. 29, 1902. No. 50837.

Prospecting for Oil in Wyoming. Prof. Arthur Lakes. A description of the prospects in the country around Medicine, Butte and Red Mountain, Uinta Co. 2700 w. Mines & Min—Oct., 1902. No. 51-043 C.

The Chanute Oil Fields in Kansas. Erasmus Haworth. Describes the location, prospecting, and development of these fields and their interesting features. 1500 w. Eng & Min Jour—Oct. 11, 1902. No. 51108.

The Present Condition of the Oil Industry of California. W. G. Young. Considers influences that have affected the industry, and difficulties that have retarded its development. 1200 w. Eng & Min Jour—Oct. 25, 1902. No. 51238.

Zinc.

Zinc in Crittenden County, Ky. George D. Wheeler. An illustrated description of the Blue & Nunn Mine, the deposits and method of mining. 1000 w. Eng & Min Jour—Sept. 27, 1902. No. 50830.

See Electrical Engineering, Electrochemistry.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Cars.

Private Cars. J. W. Midgley. An inquiry into their growth, developments and operations. 5800 w. 2 parts. Ry Age—Oct. 10 and 17, 1902. No. 51118.

Natal.

The Growing Railway System of Natal. J. Hartley Knight. An interview with the general manager, Sir David Hunter, showing the development of the system; with many illustrations. 4000 w. Engineering Magazine—Nov. 1, 1902. No. 51-393 B.

Telephone Service.

Railroad Telephone Service. Waldon Fawcett. Gives some of the uses made of this means of communication in railway service. 1500 w. Loc Engng—Oct., 1902. No. 50863 C.

FINANCIAL.

Assessment.

The True Principles for Assessment of Railway Property. Principles laid down in a decision by the Supreme Court of Nebraska. 1500 w. Ry Age—Oct. 3, 1902. No. 51001.

Panama.

The Panama Railroad. Reviews the history of this road, giving report of the earnings of the last year, and remarks on its relation to the isthmian canal project. 1500 w. Engr, Lond—Oct. 10, 1902. No. 51174 A.

Purchase.

The Atlantic Coast Line Purchase of the Control of the Louisville & Nashville. Information concerning the terms of the sale, and plans for the future development. 1800 w. R R Gaz—Oct. 3, 1902. No. 50933.

MOTIVE POWER AND EQUIPMENT.

Blast Nozzles.

Exhaust Discharge Nozzles for Locomotives (L'Echappement dans les Machines Locomotives). H. Noalhat. An

We supply copies of these articles. See page 493.

exhaustive discussion of the use of the exhaust steam to assist the draft of locomotive boilers, with illustrations of nozzles used in various countries. 4500 w. Revue Technique—Oct. 10, 1902. No. 51310 D.

Brakes.

High-Speed Brakes. The report of Mr. Nellis, with general discussion. 1200 w. Cent Ry Club—Sept. 12, 1902. No. 51177 C.

Proper Air-Brake Instructions, and Handling of Air-Brakes on Freight Trains. Extracts from a committee report to the annual meeting of the Traveling Engineers' Assn. 3000 w. Ry & Engng Rev—Oct. 4, 1902. No. 50997.

Cars.

A Combined Caboose and Repair Car. Illustrates and describes a car designed especially to accompany trains of all steel cars, thus furnishing facilities for any repairs made necessary by a collision. 900 w. Ry & Engng Rev—Oct. 11, 1902. No. 51149.

Coal Car for the Philadelphia & Reading. Illustrates and describes the latest design for a hopper bottom self-cleaning coal car of 80,000 lbs. capacity. 500 w. Ry Age—Oct. 24, 1902. No. 51264.

High Capacity Wagons. An account of tests on the North-eastern Railway to determine the most economical type for mineral traffic. Illustrates and describes the 40-ton coal wagon on trial. 2300 w. Ir & Coal Trds Rev—Oct. 3, 1902. Serial. 1st part. No. 51084 A.

New Designs of 100,000 lbs. Capacity Gondolas for the Pennsylvania. Illustrated descriptions of two new designs, one having a steel underframe with wooden body, and the other being all steel. 800 w. R R Gaz—Oct. 10, 1902. No. 51101.

Coal Trucks.

The Ownership and Capacity of Railway Coal Trucks. Discusses the tendency in England toward increasing the size of the coal cars, and the problems arising in connection with the large number of firms owning private cars. 1800 w. Jour Gas Lgt—Oct. 14, 1902. No. 51246 A.

Flues.

One Cause of Leaky Flues. S. W. Miller. Mentions the primary cause as bad water, and discusses the setting of flues. General discussion follows. 2400 w. W Ry Club—Sept. 16, 1902. No. 51179 C.

Locomotive Design.

Possibilities in American Locomotive Design. W. F. M. Goss. An address delivered at the Deer Park Convention of B. & O. officers. Reviews the past development of American roads, and discusses the characteristics of the future locomotive. 6000 w. R R Gaz—Oct. 17, 1902. No. 51226.

Locomotives.

Compound Freight Locomotive for the Norwegian State Railway (Die Verbund Güterzuglokomotive der Norwegischen Staatsbahnen). Illustrated description of ten-wheel, two-cylinder freight engine, built by the Winterthur Works. 1000 w. 1 plate. Schweizerische Bauzeitung—Oct. 4, 1902. No. 51337 B.

Fast Express Locomotive for the Big Four R. R. Illustrated description of a very heavy locomotive, with critical comments. 1000 w. Eng News—Oct. 23, 1902. No. 51283.

Passenger Locomotive for Big Four. Illustrated detailed description of a recent design of the Atlantic type. 800 w. Ry Age—Oct. 24, 1902. No. 51263.

Six-Coupled Switching Locomotive. Illustrated description of locomotives for the L. S. & M. S. Ry. designed for heavy yard service. 500 w. Am Engr & R R Jour—Oct., 1902. No. 50895 C.

Tank Engine for the Llanelly and Mynydd Mawr Railway. Illustration and particulars of a powerful side tank locomotive recently built. 250 w. Engr, Lond—Oct. 3, 1902. No. 51089 A.

Ten-Wheel Compound Passenger Locomotive, Canadian Pacific Ry. Engraving and outline diagram of recently built engine designed to burn bituminous coal. 1200 w. Ry & Engng Rev—Sept. 27, 1902. No. 50832.

Ten-Wheel Freight Locomotives for the C. H. & D. Ry. Brief illustrated description. 500 w. Ry & Engng Rev—Oct. 11, 1902. No. 51148.

Locomotive Tender.

Tender for Oil-Burning Locomotives. Illustrated description. 600 w. R R Gaz—Oct. 3, 1902. No. 50932.

Lubrication.

The Consumption of Lubricants on Prussian State Railways (Der Schmierölverbrach für die Lokomotiven der Preussischen Staats-Eisenbahnen). A. Baum. With numerous tables, showing the quantity of lubricant required per engine-kilometer and per 1000 kilometer for various kinds of locomotives. Two articles, 4000 w. Glasers Annalen—Oct. 1, 15, 1902. No. 51339 each D.

Oil Fuel.

Oil Fuel for Locomotives. Abstract of a paper by James McDonough presented before the Traveling Engrs.' Convention. Concerning the changes necessary to convert a coal to an oil burning locomotive. Also gives report of tests made by the Santa Fe Pacific R. R. to deter-

mine the relative economy of oil and coal in freight service. 1000 w. R R Gaz—Oct. 10, 1902. No. 51102.

Scrap.

Locomotive and Car Scrap. T. A. Lawes. Illustrated description of scrap bins and a report of the good results from their use. Discussion follows. 7000 w. W Ry Club—Sept. 16, 1902. No. 51178 C.

Shops.

A New Locomotive Erecting Shop (Nouvel Atelier de Montage des Locomotives). M. Desgeans. An illustrated description of the important new works of the Eastern Railway of France at Epernay. Two articles, 6 plates. Rev Gen des Chem de Fer—Sept., Oct., 1902. No. 51378 each H.

A Typical Shop to Serve a Road or Division Equipped with 300 Locomotives. L. R. Pomeroy. Extracts from a paper presented to the Mas. Mechs.' Assn. Con. Suggestions for shop construction and arrangement. Also discussion. 3000 w. R R Gaz—Oct. 24, 1902. No. 51280.

Improvements in the Schenectady Works of the American Locomotive Co. Illustrates and describes new buildings, including a boiler shop, foundry, blacksmith shop, tank shop, hammer shop and drop forge shop, besides minor structures. 1600 w. R R Gaz—Oct. 3, 1902. No. 50931.

New Locomotive and Car Shops. The first of a series of illustrated articles describing the new shops at Collinwood, Ohio. 4000 w. Am Engr & R R Jour—Oct., 1902. Serial. 1st part. No. 50891 C.

San Bernardino Shops of the Santa Fe System. Illustrated description of the complete transformation of the old plant, with new construction and additions which will give a new arrangement throughout. 1200 w. Ry Age—Sept. 26, 1902. No. 50831.

The Memphis Shops of the Illinois Central. Illustrates and describes improvements that will greatly increase the present terminal facilities. 1100 w. R R Gaz—Oct. 17, 1902. No. 51227.

Stoker.

The Kincaid Locomotive Stoker. Illustrates and describes an invention which gives promise of great utility, adding to the efficiency, economy and abatement of smoke in locomotives. 1000 w. Sci Am Sup—Oct. 25, 1902. No. 51296.

Superheated Steam.

The Use of Superheated Steam in Locomotives. Condensed translation from *Glaser's Annalen für Gewerbe und Bauwesen*, discussing the use of the Schmidt superheater on German locomotives. Ill. 3000 w. R R Gaz—Oct. 10, 1902. No. 51103.

Train Lighting.

Electric Train-Lighting in Germany. Editorial review of an interesting paper by Herr Geheimer Oberbaurath Wichert, printed in the *Glaser's Annalen*, giving particulars of recent experiments in the matter of train-lighting by electricity, carried out in the Prussian State Railways. 1500 w. Engng—Oct 10, 1902. No. 51170 A.

Water Service.

Improvement of Water Service on Railways. Describes the work of improving the water for locomotive service as carried out by a company in Chicago, which has in course of construction, 16 plants with a capacity of 3,756,000 gals. per day. Ill. 4300 w. Ry & Engng Rev—Oct. 18, 1902. No. 51210.

NEW PROJECTS.

China.

Chinese Railway Development. An account of what has been accomplished in railway building. 1200 w. Transport—Oct. 3, 1902. No. 51057 A.

Engadine.

The Engadine Railway (Le Chemin de Fer de l'Engadine). H. Martin. A fully illustrated account of the construction of a narrow gauge steam railway, from Coire to St. Moritz, Switzerland. The Albula tunnel and several important viaducts are discussed. 3000 w. 1 plate. Génie Civil—Oct. 4, 1902. No. 51304 D.

Inclined Railway.

The Weehawken Inclined Railway. Charles L. Duenkel. An illustrated description of a road which runs from the lowlands to the Mountain Road at the top of the Palisades, opposite New York. 4500 w. Eng News—Oct. 16, 1902. No. 51216.

PERMANENT WAY AND FIXTURES.

Construction.

Railway Building Through a Forest. Illustrated description of work on the Hoquiam branch of the Northern Pacific R. R. in the state of Washington. 800 w. Ry Age—Oct. 3, 1902. No. 51000.

Cut-Off.

Ogden-Lucin Cut-Off—Central Pacific Ry. An account of progress of this work, which crosses the Great Salt-Lake, and the interesting methods of construction. Ill. 2000 w. R R Gaz—Oct. 24, 1902. No. 51279.

Embankments.

The Construction and Maintenance of Railway Embankments. Editorial discussion of practice in America and in England, and the causes of settlement, slip-

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ping, etc. 2000 w. Eng News—Oct. 9, 1902. No. 51097.

Improvements.

Reconstruction of the Richmond-Washington Line. Brief account of changes, including the double-tracking of the entire line. 600 w. Ry Age—Oct. 3, 1902. No. 50999.

Office Buildings.

The Grand Trunk's New Office Building. Illustrated detailed description of this recently completed fine building in Montreal. 1300 w. Ry Age—Oct. 17, 1902. No. 51193.

Rails.

Steel Rails: Specifications. Robert Job. Gives the Philadelphia & Reading Railway Company's Specifications, and information gained by careful investigations and experience. 2700 w. Am Engr & R R Jour—Oct., 1902. No. 50893 C.

Renewal.

The Quick Renewal of Permanent Way. Considers methods and points needing care, and means of avoiding accidents while the work is in progress. 5000 w. Engr, Lond—Oct. 17, 1902. No. 51418 A.

Round-Houses.

Increased Light for Round-Houses. T. A. Lawes. Brief illustrated description of a method of wall construction permitting larger window area. 500 w. Am Engr & R R Jour—Oct., 1902. No. 50892 C.

Signals.

Electro-Pneumatic Interlocking at Albany. Diagrams showing the tracks and signals, with explanatory notes. 600 w. R R Gaz—Oct. 24, 1902. No. 51277.

The Taylor Electric Interlocking System. An illustrated detailed description of this system and its working. 5400 w. Eng News—Oct. 2, 1902. No. 50929.

The Union Electric Semophore Signal. Illustrates and describes the mechanism and electric connections of an automatic system of railway signalling. 1100 w. Sci Am Sup—Oct. 25, 1902. No. 51294.

TRAFFIC.

Freight.

Freight Rates in Illinois. Statement in full of the C. B. & Q. Railway to the Quincy Freight Bureau. 3200 w. Ry Age—Oct. 17, 1902. No. 51194.

Ireland.

The Belfast and Northern Counties Railway. Reviews the history of this line, soon to be amalgamated with the Midland Railway Company. Ill. 3000 w. Transport—Oct. 10, 1902. No. 51153 A.

New Zealand.

New Zealand Government Railways. Information from the railways statement for the year ending March 31, 1902, with map. 1200 w. Transport—Sept. 19, 1902 Serial. 1st part. No. 50960 A.

"Owner's Risk."

The Railway Companies and "Owner's Risk." Discusses a proposed alteration which the British railway companies are endeavoring to carry through. 1700 w. Engr, Lond—Sept. 26, 1902. No. 50968A.

Tractive Force.

The Tractive Force of Locomotives. Edward L. Coster. Most of the article is a compilation from the paper entitled "Practical Tonnage Rating," presented at the 1901 convention of the Master Mechanics' Assn., by George R. Henderson, and from information supplied in private correspondence. 1700 w. Am Engr & R R Jour—Oct., 1902. No. 50896 C.

STREET AND ELECTRIC RAILWAYS

MISCELLANY.

Acceleration.

The Liverpool Overhead Railway. Results of high acceleration extracted from a recently issued pamphlet. 2000 w. Transport—Oct. 17, 1902. No. 51407 A.

The Relation of Energy and Motor Capacity to Schedule Speed in the Moving of Trains by Electricity. Discussion of Dr. Cary T. Hutchinson's paper. Plates. 12300 w. Trans Am Inst of Elec Engrs—June & July, 1902. No. 51138 D.

Accidents.

The Accident on the Glasgow Tramways. Full report made to the Board of Trade by the inspector who inquired into the accident. 2000 w. Elect'n, Lond—Oct. 17, 1902. No. 51415 A.

Address.

President Vreeland's Address before the American Street Railway Association. Remarks on the legal and social state of electric railroads, and the problems to be solved in connection. 3000 w. St Ry Rev—Oct. 9, 1902. No. 51225 C.

Benefit Associations.

Street Railway Mutual Benefit Associations. Oren Root, Jr., Read at the Detroit meeting of the St. Ry Con. Gives details of the workings of the Metropolitan Street Railway Association of New York. 2700 w. St Ry Jour—Oct. 11, 1902. No. 51145 D.

Berlin.

The Latest Developments of the Berlin Elevated and Underground Railway.

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Frank C. Perkins. An illustrated description of the line and its equipment. 2800 w. Elec Rev, N Y—Oct. 11, 1902. No. 51106.

Car Control.

Tram Car Driving. H. B. Phillimore. Describes the equipment for controlling the car, and its manipulation, giving suggestions for motor-drivers. 1700 w. Elec Rev, Lond—Oct. 10, 1902. No. 51161 A.

Car Equipment.

Interurban Electric Railway Car Equipment. W. B. Potter. Discusses some of the conditions met with in determining the equipment for various types of service, describing only such apparatus as has passed the experimental stage. 3500 w. St Ry Jour—Oct. 4, 1902. No. 50988 D.

Cars.

Cars for High Speed Interurban Service. An illustrated study of some of the recent designs used by electric interurban railways. 3700 w. St Ry Jour—Oct. 4, 1902. No. 50992 D.

Car Tests.

Tests of Interurban Cars of Union Traction Company of Indiana. Clarence Renshaw. A report of tests made between Muncie and Indianapolis, with curves showing results. Ill. 3800 w. St Ry Jour—Oct. 4, 1902. No. 50990 D.

Construction.

The Artistic Treatment of Electric Railway Line Construction. H. P. Quick. Illustrates many pole designs for the support of the wires. Compares American and foreign practice. 1200 w. St Ry Rev—Sept. 20, 1902. No. 50908 C.

Damage Claims.

The Adjustment of Damage Claims. Mason B Starring. Discusses some of the difficulties, offering suggestions concerning adjustment. 5400 w. St Ry Rev—Oct. 11, 1902. No. 51190 C.

Detroit.

Detroit as an Interurban Electric Railway Center. Map and information, showing the great number of interurban lines centering in this city. 1500 w. St Ry Jour—Oct. 4, 1902. No. 50975 D.

Flint Division of Detroit United Railway Company. S. T. Dodd. Illustrates and describes a plant of S. K. C. rotaries which works very successfully on this long distance line. 2800 w. Elec Wld & Engr—Oct. 4, 1902. No. 51018.

Motive Power and Rolling Stock of the Detroit United Railway. Thomas Farmer. Illustrated detailed description of the power houses and battery stations, and various types of cars, etc. 3700 w. St Ry Jour—Oct. 4, 1902. No. 50977 D.

Motive Power and Rolling Stock on the Rapid Railway. Illustrates and describes these features of the Detroit & Port Huron Shore Line Railway. 1500 w. St Ry Jour—Oct. 4, 1902. No. 50982 D.

Overhead Construction and Electric Power Distribution of the Detroit United Railway System. An illustrated article describing types of construction, materials, power distribution, and the work in general. 2200 w. St Ry Jour—Oct. 4, 1902. No. 50980 D.

Power Stations of the Detroit United Railway. Thomas Farmer. Illustrated detailed description. 2800 w. St Ry Rev—Sept. 20, 1902. No. 50904 C.

Review of the Detroit United Railway System from an Operating Standpoint. A. H. Stanley. Map and illustrations. 3500 w. St Ry Rev—Sept. 20, 1902. No. 50903 C.

The General Passenger Department of the Detroit United Railway System. Explains conditions and discusses the work of this department. 2000 w. St Ry Jour—Oct. 4, 1902. No. 50981 D.

The Rapid Railway System. F. W. Brooks, W. O. Wood and A. C. Marshall. An illustrated article giving a full account of the Detroit & Port Huron Shore Line Railway, its equipment and operation. 3800 w. St Ry Rev—Sept. 20, 1902. No. 50905 C.

The Street Railways of Detroit. An illustrated article giving the history of their development, with a review of the agitation for low fares, and a table showing the relations of the different companies forming the Detroit United Railway. 4500 w. St Ry Rev—Sept. 20, 1902. No. 50902 C.

Discipline.

Discipline for Street Railway Employes. W. F. Harrington. Gives rules for the government of conductors and motormen on the Camden & Suburban railway, and the results of the "demotion" system, describing its essential features. 2200 w. St Ry Rev—Sept. 20, 1902. No. 50910 C.

Electric Locomotive.

A 10,000-Volt Locomotive. Illustrated detailed description of a locomotive built for the high-speed, high-pressure electric railway experiments near Berlin. 2000 w. Elect'n, Lond—Oct. 17, 1902. No. 51414 A.

Electric Traction.

Electric Traction in Its Relation to Existing Railways. J. W. Jacomb-Hood. Extract from a paper read before the London and South-Western Ry. Debating Soc. Discusses mainly its application to suburban service, and the cost. 2000 w. Elect'n, Lond—Oct. 17, 1902. No. 51416A.

We supply copies of these articles. See page 493.

Elevated Railway.

Application of Electric Traction to the New York Elevated Railways (Application de la Traction Electrique au Chemin de Fer Metropolitain de New York). H. Martin. A description of the conversion of the New York elevated railway system from steam to electric traction. Serial. Part I. 3000 w. 1 plate. Génie Civil—Sept. 13, 1902. No. 51300 D.

England.

Suburban Traffic Conditions of London, England. Philip Dawson. An explanation of the conditions, and the system of railway lines existing and proposed which are expected to meet all requirements. Maps. 6000 w. St Ry Jour—Oct. 4, 1902. No. 50991 D.

Europe.

Electric Railway Schemes in Europe. A statement of present conditions, and what is being done at various centers. 1700 w. Engr, Lond—Oct. 17, 1902. No. 51419 A.

Exposition.

Electric Railways and the St. Louis Exposition. W. E. Goldsborough. An illustrated article giving information concerning the transportation and electrical buildings and electric railway exhibits. 2800 w. St Ry Rev—Oct. 20, 1902. No. 51243 C.

Fares.

Collection and Registration of Fares on City and Suburban Lines. William C. Sampson. Read at meeting of St. Ry. Accountants' Assn. Briefly describes the various systems tried by the Union Traction Co. of Indiana. 2700 w. St Ry Rev—Oct. 9, 1902. No. 51186 C.

Freight.

Electric Express and Package Delivery. George Parker. Read at the Detroit meeting of the St. Ry. Con. Describes the system, methods employed, and general management of the express business on the roads about Detroit. 3500 w. St Ry Jour—Oct. 11, 1902. No. 51147 D.

Freight Business on Detroit Interurban Roads. An illustrated account of methods of conducting an extensive business in competition with steam roads. 1500 w. St Ry Jour—Oct. 4, 1902. No. 50979 D.

Handling Freight and Express on Interurban Electric Railways. Albion E. Lang. Describes this work as carried out on the interurban roads of Northwestern Ohio. Ill. 3800 w. St Ry Jour—Oct. 4, 1902. No. 50986 D.

Interurban.

An Electric Traction System Employing Single-Phase Alternating Current. Gives the paper describing this new system, presented by B. G. Lamme, at the recent meeting of the Am. Inst. of Elec. Engrs., with editorial comment. 5300 w. Eng News—Oct. 2, 1902. No. 50927.

From the Lake Region to the Atlantic Sea Board by Trolley. R. H. Derrah. An illustrated account of a trip from Port Huron, Mich., eastward to the sea. Brief descriptions of many lines and the towns and cities through which they pass. Maps. 10300 w. St Ry Rev—Oct. 20, 1902. Serial. 1st part. No. 51244 C.

Interurban Road Through Ohio Oil Field. Illustrated description of the Toledo, Fostoria & Findlay Railway, and its operation. 2000 w. St Ry Jour—Sept. 27, 1902. No. 50835 D.

Power Distribution and Operating Points on the Detroit, Ypsilanti, Ann Arbor & Jackson Railway. An illustrated article considering points of interest in the working of this long interurban electric road. 2000 w. St Ry Jour—Oct. 4, 1902. No. 50984 D.

Single Phase Electric Railway System. B. G. Lamme. Read at meeting of the Am. Inst. of Elec. Engrs. A description of the new high-speed electric line extending from the suburbs of Washington to Baltimore, with a branch to Annapolis. 8000 w. Elec Wld & Engr—Oct. 4, 1902. No. 51021.

The Accounting Department of Interurban Railways. W. B. Brockway. Discusses the many problems that arise in planning a system of accounting. 6800 w. St Ry Jour—Oct. 4, 1902. No. 50987 D.

The Aurora, Elgin & Chicago Railway. This noted interurban road is especially notable for its speed. This article discusses the elements which make this speed possible. Ill. 6600 w. St Ry Jour—Oct. 4, 1902. No. 50995 D.

The Boston & Worcester Street Railway. An illustrated description of one of the latest interurban roads of New England, representing the most advanced practice. 5700 w. St Ry Jour—Oct. 4, 1902. No. 50993 D.

The Oley Valley Railway. Illustrates and describes one of the most interesting interurban lines in Pennsylvania. 4000 w. St Ry Jour—Oct. 4, 1902. No. 50994 D.

The Operation of Electric Interurban Railways. W. O. Wood. Discusses the problems and needs of these roads. 2500 w. St Ry Jour—Oct. 4, 1902. No. 50983 D.

The System of the Detroit, Ypsilanti, Ann Arbor & Jackson Railway. F. E. Merrill. Illustrates and describes this road which was the first to construct 40 miles of track. 3500 w. St Ry Rev—Sept. 20, 1902. No. 50906 C.

Track and Overhead System for an Interurban Electric Railway. Concerning

We supply copies of these articles. See page 493.

the economy and advisability of the best construction, with estimate of cost. 3500 w. St Ry Rev—Oct. 20, 1902. No. 51-245 C.

London Tramways.

The Electrification of the South London Tramways. Begins an account of the work of reconstruction, stating why the conduit system was adopted, and the proposed extensions. Ill. 1800 w. Engng—Oct. 3, 1902. Serial. 1st part. No. 51-091 A.

Repair Shops.

The Most Economical Management of the Repair Shop. Charles S. Banghart. Read at meeting of the Penn. St. Ry. Assn. Gives a list of machines found most generally useful, with suggestions as to their arrangement, and the work of the shop in general. 1700 w. St Ry Rev—Sept. 20, 1902. No. 50909 C.

Rolling Stock.

New Fireproof Rolling Stock for the Central London Underground Railway. Gives an illustrated abstract of the plans and specifications of the motor cars and other parts of the equipment. 3000 w. St Ry Jour—Oct. 11, 1902. No. 51144 D.

Rules.

Report of Committee on Standard Code of Rules for the Government of Conductors and Motormen. Submitted at the Caldwell meeting of the St. Ry. Assn. 4000 w. St Ry Jour—Sept. 27, 1902. No. 50-836 D.

Signals.

Signals for Urban and Interurban Railways. G. W. Palmer, Jr. Read before the Am. St. Ry. Assn. Shows the growing need of the best signal system possible, and discusses the requirements. 1700 w. St Ry Rev—Oct. 11, 1902. No. 51-189 C.

Stray Currents.

The Electrolytic Action of Currents upon Buried Pipes (Ueber den Elektrolytischen Angriff Elektrischer Ströme auf Eisenröhren in Erde). A. Larsen. A review of experiments made upon buried iron pipes at the Technical High School of Copenhagen. 1200 w. Elektrotech Zeitschr—Sept. 18, 1902. No. 51352 B.

The Prevention of Electrolysis of Gas and Water Pipes in Great Britain. A review of steps taken by the British Board of Trade, presented by W. H. Humphreys at the recent meeting of the Brit. Assn. of Water-Works Engrs. 1700 w. Eng News—Oct. 2, 1902. No. 50928.

The Prevention of Electrolysis by Periodical Reversal of Current (Ueber Periodische Stromwendung als Mittel zur Verringerung Elektrolytischer Zerstörungen). A. Larsen. Data and results of experiments showing that electrolytic corrosion of buried pipes may be greatly diminished by daily or hourly reversal of the flow of current. 1500 w. Elektrotech Zeitschr—Sept. 25, 1902. No. 51358 B.

Surface Contact.

The "Dolter" Surface Contact System. A review of a book giving an illustrated detailed description of this system. 2800 w. Elec Rev, Lond—Sept. 19, 1902. No. 50852 A.

Tracks.

The Construction of Perfect Track. Two short papers by J. C. Brackenridge and R. Trimble, with general discussion. 11000 w. N Y R R Club—Sept. 18, 1902. No. 51123.

Track Construction and Maintenance on the Detroit United Railway. Illustrated article describing methods and machines used in constructing and maintaining about 188 miles of city track and 192 miles of interurban track. 3000 w. St Ry Jour—Oct. 4, 1902. No. 50978 D.

Tramways.

Procedure on Application for a Tramway Order. Outlines the procedure which must be observed by those who promote an electric tramway in England or Wales. 1400 w. Elec Rev, Lond—Sept. 26, 1902. Serial. 1st part. No. 50959 A.

Transfers.

Registration of Transfers. C. D. Meneely. Read at Detroit meeting of the St. Ry. Con. Outlines the arguments for and against the registration of transfers with a view of determining evidence from which to draw a conclusion. 1500 w. St Ry Jour—Oct. 11, 1902. No. 51146 D.

Trolley Wires.

Trolley Wires of Special Section (Der Profil draht). Max Schiemann. A discussion of the so-called "hour-glass" section and other special shapes for trolley wires, with regard to the methods of supporting, joining, and protecting them. 1500 w. Elektrotech Zeitschr—Sept. 18, 1902. No. 51353 B.

Trucks.

Trucks for Interurban Service. C. F. Uebelacker. Gives the conditions to be met by a truck intended for high-speed service, and gives illustrated descriptions of various types. 4200 w. St Ry Jour—Oct. 4, 1902. No. 50989 D.

Tyneside.

The Tyneside Tramways and Tramroads. Brief illustrated description of this recently opened line. 3400 w. Elec Engr, Lond—Oct. 3, 1902. No. 51074 A.

We supply copies of these articles. See page 493.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Am. Manuf. and Iron World. *w.* Pittsburg, U. S. A.
American Shipbuilder. *w.* New York.
American Telephone Journal. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Armee und Marine. *w.* Berlin.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile Magazine. *m.* New York.
Automotor & Horseless Vehicle Jl. *m.* London.
Brick Builder. *m.* Boston.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin Scientifique. *m.* Liege.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Electrochemist & Metallurgist. *m.* London.

Elektrizität. *b-w.* Leipzig.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Horseless Age. *w.* New York.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strausseubahnen. *s-m* Berlin.
Indian and Eastern Engineer. *m.* Calcutta.
Ingeneria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metallographist. *qr.* Boston.
Metal Worker. *w.* New York.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d Kgl Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Monatsschr. d Wurtt. Ver. f Baukunde. *m.* Stuttgart.
Moniteur Industriel. *w.* Paris.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Wochenschr. f. d. Oeff Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Power Quarterly. New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Procedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'Way Club. *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Digest. *w.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. ed Agr. *b-m.* Catania.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Sanitary Plumber. *s-m.* New York.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Stahl und Eisen. *s-m.* Düsseldorf.
Steam Engineering. *m.* New York.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Telephone Magazine. *m.* Chicago.
Telephony. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining. Eng. New York.
Trans. Am. Soc. of Civil Eng. *m.* New York.
Trans. Am. Soc. of Heat & Ven. Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Western Electrician. *w.* Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Yacht. *w.* Paris.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.

CURRENT RECORD OF NEW BOOKS

NOTE—Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post-Office Orders, home and foreign, should be made payable to THE ENGINEERING MAGAZINE.

Cuba.

Report of Major W. M. Black, Corps of Engineers, U. S. A., Chief Engineer Department of Cuba. Volumes XI and XII of the Civil Report of Major General Leonard Wood, Military Governor of Cuba. Size, 9½ in. by 6¾ in.; pp. (Vol. XI.) 264, (Vol. XII.) 425; maps and illustrations. Paper binding.

These reports cover respectively the fiscal year ending June 30, 1900, and the six months ending Dec. 31, 1900. They are couched in the formal language of government documents, but their unadorned record of work performed is wonderfully impressive. The reports cover the whole of Cuba, and describe a great variety of engineering and sanitary work, including pavements, sewers, parks, harbor improvements, water-works, hospitals, prisons, etc. Amid difficult and trying circumstances, the United States army engineers have performed their task with wisdom and fidelity, and with the most satisfactory results. No Cuban can read this straightforward account of the renovation of the Pearl of the Antilles without a feeling of gratification, and no American without a sense of pride.

Framed Structures.

The Mechanics of Engineering. Vol. II. The Stresses in Framed Structures, Strength of Materials and Theory of Flexure; Also the Determination of Dimensions and Designing of Details, Specifications, Complete Designs and Working Drawings. By A. Jay DuBois, C. E., Ph. D. Size, 11 in. by 8 in.; pp. XXIII, 609; figures, 300; plates, 50. Price, $10. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

This is the twelfth revised edition of "The Stresses in Framed Structures," by the professor of civil engineering in the Sheffield Scientific School of Yale University, and, although issued as Vol. II of "The Mechanics of Engineering," is complete in itself. This work is a very complete exposition of the theory and practice of the design of bridges and other framed structures. In the present edition the "principles of least work" has been successfully applied to the solution of many problems, including those of the continuous girder, the swing bridge, the arch and the suspension bridge. There are given general specifications for steel railroad bridges and viaducts, by Theodore Cooper, and a list of the different members in a bridge, by Prof. J. A. S. Waddell. There is a chapter on modern high buildings by William W. Crehore, and one on erection, by J. S. Deans. The volume is profusely illustrated, and is of great value both as a text book for the engineering student and a work of reference for the professional engineer.

Gas Testing.

Gas Analyst's Manual (Incorporating F. W. Hartley's "Gas Analyst's Manual" and "Gas Measurement.") By Jacques Abady, M. Inst. Mech. E. Size, 9 in. by 6 in.; pp. XV, 561; illustrations, 102; tables. Price, $6.50. London: E. & F. N. Spon, Ltd. New York: Spon & Chamberlain.

This is a very complete treatise on the testing of illuminating and heating gas, written from a British standpoint. Besides the testing of the gas itself, tests for all the materials entering into the manufacture of gas are described. Though founded on the works of the late F. W. Hartley, as mentioned in the title, this volume has been amplified to have a far wider scope, and Mr. Hartley's books are incorporated in only three chapters and occasional paragraphs. In the present volume, there are chapters on photometry; standards of light; calorimetry and specific gravity; tests for sulphur and ammonia; coal testing; testing of enrichment and purification materials; quick gas-works tests; testing of bye-products; technical gas analysis; and meter and governor testing. An appendix contains many useful tables and data. The book is handsomely made and bound, and is altogether a most comprehensive manual of testing for the gas-works engineer.

Gearing.

Worm and Spiral Gearing. By Frederick A. Halsey. Size, 6 by 3¾ in.; pp. 85; figures, 23. Price, 50 cents. New York: D. Van Nostrand Company.

This is one of the Van Nostrand Science Series, and reprinted from the "American Machinist," of which the author is associate editor. The theory of the efficiency of worm gearing is laid down, and the advantage of a large angle of thread is

clearly shown. This theory is supported by facts drawn from experience, and it points out clearly the procedure to be followed in order to insure durability and efficiency. In the second part of the work, both analytical and graphical methods of laying out spiral gearing are given, and the subject is ably discussed.

Industrial Conciliation.

National Conference on Industrial Conciliation, Under the Auspices of the National Civic Federation, Held at Rooms of Board of Trade and Transportation, New York, December 16 and 17, 1901. Size, 7½ by 5 in.; pp. 278. Paper binding. Price, $1.25. New York: The Knickerbocker Press (G. P. Putnam's Sons).

Part I of this book consists principally of a complete stenographic report of the above conference, including addresses by leading representatives of capital, of labor and of the general public. There are also a list of the industrial committee, appointed after the adjournment of the conference, consisting of 36 members representing the public, the employers and the wage earners, and this committee's "statement of purpose." Part II contains the more important papers read at the Chicago conference of the National Civic Federation, held on December 17 and 18, 1900. Appendix I has the "Appeal to the American People," adopted at the Chicago conference, and Appendix II is the address of this conference's National Committee on Conciliation and Arbitration, issued May 8, 1901, at New York. On the whole, this little volume gives a clear view of one of the most notable attempts that has been made to get "capital" and "labor" together and make them understand each other, so that they will see that their true interests are not conflicting, but harmonious.

Shipyard.

Cramp's Shipyard, 1830-1902. Size, 8 by 5½ in.; pp. X, 180; illustrations, 26. Philadelphia: The William Cramp & Sons Ship and Engine Building Co.

This book is printed for private circulation by the great shipbuilding company which has had so large a share in creating a new navy for the United States. It contains a brief history of the business which was founded on a modest scale by William Cramp in 1830, and which has since grown to such enormous proportions. There are beautiful illustrations and descriptions of the more important of the 321 sea-going vessels of all classes which have been built in Cramp's shipyard, including United States, Russian, Japanese and Ottoman men-of-war. The volume is elegantly and tastefully made in every respect, and is an appropriate epitome of a great enterprise.

Timber.

Timber. A Comprehensive Study of Wood in all its Aspects, Commercial and Botanical. Translated from the French of Paul Charpentier by Joseph Kennell. Size, 10 by 6½ in.; pp. 437; illustrations, 179. Price, $6. London: Scott, Greenwood & Co. New York: D. Van Nostrand Company.

This book covers broadly the whole timber field, starting with the growing tree and carrying the history of wood down to the point where it is ready for the multitudinous uses to which it is put. Divisions of the book are devoted to the physical and chemical properties of wood; description of the different species of wood; the useful varieties of timber in the different countries of the world; forests, their improvement, preservation and exploitation; the preservation of timber, including fireproofing; and the applications and products of timber, this last part including building timber, paving wood, mine timber, railway cross-ties, gums, resins, bark, tanning materials, cork, dyewoods, oil of wood and miscellaneous wood products.

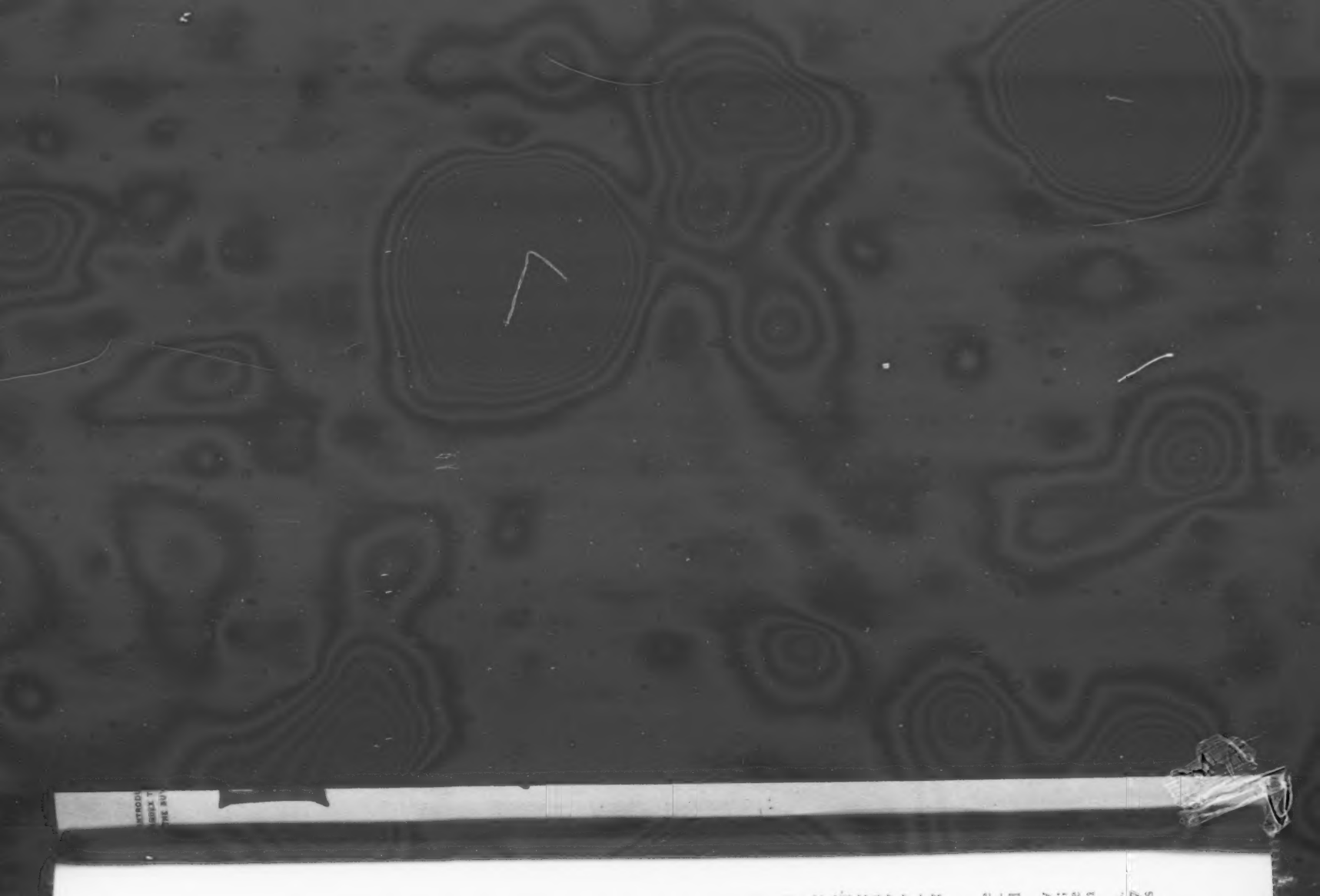
Wood Turning.

A Manual of Wood Turning. By C. R. Richards, M. M. E., Professor of Mechanical Engineering at the University of Nebraska. Size, 13 by 12 in.; pp. 20; figures, 64. Price, $1.00. Lincoln, Neb.: The University Book Store.

This manual presents in a concise manner the methods employed in the turning of wood. In order to best adapt it for use in the college shop, where a treatise in book form would be inconvenient, it is printed on separate large sheets, on only one side of the paper. These sheets are perforated so that they can be kept together in a cloth binder. After describing a wood lathe and the tools in general use, a number of exercises are taken up and detailed directions for properly executing them are given. The exercises have been used in practical instruction for many years, and the whole manual has a very workmanlike look and is peculiarly adapted to the needs of mechanical engineering students.

BOOKS ANNOUNCED.

Twenty-Third Annual Report of the Ohio Society of Surveyors and Civil Engineers. W. H. Boughton, Secretary and Treasurer, Granville, Ohio.

American Municipal Progress. By Charles Zueblin. Size, 7½ by 5 inch.; pp. 380. Price, $1.25. New York: The Macmillan Company. London: Macmillan & Co., Ltd.

Le Béton Armé et Ses Applications. 2d ed. By Paul Christophe. 8vo; 847 figures. Price, 25 francs ($7.50). Paris and Liège: Ch. Béranger.